Report.

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

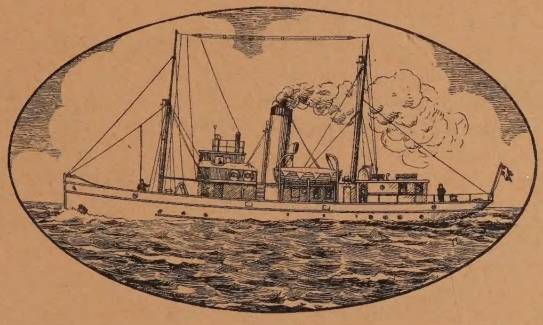
Report

of

The Danish Biological Station

to

The Ministry of Shipping and Fisheries



XXXIX

1934.

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A. Reitzel.
1935.

The Reports from the Danish Biological Station (Nos. I—XXI) are published in the official Danish "Fiskeri-Beretning" for the years 1890—91 until 1912. After this year they appear as special publications. The Reports I—XXXII are edited by the late Dr. C. G. Joh. Petersen, the Reports XXXIII—XXXVI by Dr. A. C. Johansen and the later Reports by Dr. H. Blegvad.

I. *C. G. Joh. Petersen:* Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91)*) 63 pp. 1 Chart. Out of print.

II. *Idem:* On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pp. Two Plates. Out of print.

III. *Idem:* The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pp. Tables. Out of print.

IV. *Idem:* On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pp. 2 Plates. 1 Chart. Many Tables. Out of print.

V. *Idem:* The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pp. With 2 Plates.
Etc. 64 pp. Out of print.

VI. *Idem:* The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96). 48 pp. 1 Chart. 2 Tables. Out of print.

VII. *Idem:* Plankton-Studies in the Limfjord. 1897. 23 pp. 1 Map. 4 Tables. Out of print.

VIII. *Idem:* An Otter-Seine for the Exploration of Deeper-Seas. 1898. 24 pp. With 10 Figures. Out of print.

IX. *Idem:* Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pp. With one Map. Out of print.

X. *Idem:* List of the "Aalerusestader" in Denmark etc. — Smaller Communications. 1899 and 1900. 37 pp.

XI. *Idem:* I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pp.

XII. *Idem:* I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus.* (With one Plate). III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pp.

XIII. *A. Otterstrøm:* Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pp.

XIV. I. *C. G. Joh. Petersen:* The Influence of Light on the Migrations of the Eel. II. *K. I. Gemzøe:* Age and Rate of Growth of the Eel. 1906. 39 pp.

XV. *Idem:* I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pp.) 1908.

XVI. *C. H. Ostenfeld:* On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. With 9 figures. 1908. 62 pp.

XVII. *C. G. Joh. Petersen:* II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pp).

XVIII. *C. G. Joh. Petersen:* I. The Yield of the Limfjord fisheries in recent years and the transplantation of Plaice in 1908. With 6 tables and 1 Chart. II. Biological investigations on the stock of Plaice in the Limfjord. With 3 Tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 Tables. 25 pp. 1909.

XIX. *Idem:* Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord. 20 pp. 1911.

XX. *C. G. Joh. Petersen* og *P. Boysen Jensen:* Valuation of the Sea. I. Animal Life of the Sea-Bottom, its food and quantity. With 6 Tables, 3 Charts and 6 Plates. 81 pp. 1911.

*) The figures in ( ) refer to the "Fiskeri-Beretning" for the years quoted.

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

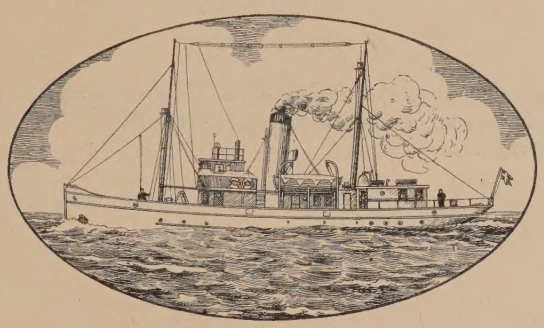
Report

of

The Danish Biological Station

to

The Ministry of Shipping and Fisheries



XXXIX

1934.

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A. Reitzel.
1935.

CONTENTS

Page

H. Blegvad: An Epidemic Disease of the Eel-Grass (*Zostera marina* L.) 1

H. Blegvad: Transplantations of Plaice from the North Sea to the Belt Sea 1928—1933. The Scientific Survey 9

H. BLEGVAD:

An Epidemic Disease of the Eel-Grass (*Zostera marina* L.).

H. BLEGVAD.

An Epidemic Disease of the Eel-Grass (*Zostera marina* L.).

The eel-grass, *Zostera marina*, is one of the few flowering plants that are found in the sea. Its distribution is extensive — i. a. it is found at both coasts of the Atlantic and rather far towards the North. In our waters it generally makes up vast green submarine beds in places where the water is comparatively calm and the sea-floor fairly soft, from the coast line to depths of a dozen yards. It is lacking along nearly the whole of the western coast of Jutland, where the washing of the sea, the currents, and the hard sea-bottom hinder its growth; the Limfjord and the waters South of Zealand and Funen are its most favourable habitats. In such places the long, articulated rhizomes traverse the ground like a close network, and the yardlong narrow leaves shelter a rich animal life; a great many crustacea and small fish find their food and shelter here: Prawns, Amphipods, Stickle-backs, Gobies, *Spinachia* etc., and among animals of direct economic importance the young cod and the eel of all fish live here.

But the importance of the eel-grass is of a far wider scope than that of being the basis of a rich animal life at the coasts. When the autumnal gales break off the leaves with their many small air-spaces, they keep afloat at the surface; by wind and current they are carried to the deep water where they gradually sink to the bottom as minute brown fragments; thus the seaweeds of the coastal areas carry vegetable aliment to the bottom of the deep water, where otherwise no plant can thrive on account of the want of light, a vital necessity of all producing plants.

The growth and occurrence of the eel-grass in Denmark were closely studied by C. H. Ostenfeld (From the Danish Biol. Station XVI, 1908). C. G. Joh. Petersen (Mindeskrift (Commemorative publication) for Japetus Steenstrup, 1913) in studying the structure of the rhizome found that each rhizome produces about 10 joints in summer and about half the number in winter. The latter are shorter and carry shorter leaves. Each joint carries a leaf, but there are rarely more than 5 leaves at a time on each rhizome because the old leaves gradually wither and fall off. So the amount of green leaves, which can be gathered in 1 sq. m. of a *Zostera* bed, constitutes about half the production in summer and less than half the annual production. Dr. Petersen found that where the eel-grass grows vigorously there are about 6,000 gr. of leafage per sq. m. and in places of sparse growth about 1,700 gr. per sq. m. The annual production, which was twice the quantity without regard to the winter leaves, consequently ranges between 12,000 and 3,400 gr. per sq. m. The percentage of dry matter being 16, these figures correspond to respectively 1,920 and 544 gr. of dry matter per sq. m. The areas of eel-grass along the Danish coasts cover about 3,430,000 sq. m., and through a cautious average calculation of the production Dr. Petersen arrives at the result that within the said area the eel-grass produces about 8,232 mill. kg. of dry matter a year, i. e. nearly 4 times as much as the whole Danish production of hay.

Besides being of fundamental importance to the animal life of the sea the eel-grass plays rather a great part as an industrial article. It is gathered along the coasts and used as manure and for insulating and upholstering purposes, etc.

Consequently, it created a considerable sensation when in 1932 a disease was observed to waste the eel-grass along the coasts of Portugal, France, and Holland. Symptoms of the disease are in the first place that brown specks appear on the leaves, especially at the extreme ends; gradually these specks spread over the leaf and also affected the rhizome.

At last the leaves grew black and fell off. But on account of the fact that also the inner dissepiments of the air-spaces were affected the leaves did not keep afloat as the detached *Zostera*-leaves use to do, but sank to the bottom. In the course of a short time large luxuriant eel-grass beds were converted into black fetid masses on the bottom.

At the end of 1932 and the beginning of 1933 questionaries were sent to various countries both from the "Laboratoire de Cryptogamie" in Paris and from Dr. B. Havinga, Laboratory for Inland Fisheries in Amsterdam, with inquiries whether the disease had been observed in the countries in question. As for Denmark I was then able to answer in the negative, but later on conditions have changed completely.

The first signals of danger came from the Limfjord where fishermen had noticed that the eel-grass had disappeared from Nissum Bredning, the large western broad, already at the beginning of 1933. Starting from this fact and having myself investigated the matter in different places I applied to the Fishery Patrol, and by the kind assistance of Messrs Trolle-Thomsen and A. Jørgensen, Fishery Inspectors for the islands and for Jutland, respectively, I sent out inquiry forms to the fishery assistants all over the country. The text of the forms was as follows:

1. Did you observe a disappearance of the eel-grass your district?
   and if so:
2. In which places?
3. When did the eel-grass begin to disappear?
4. Was it of an extraordinary appearance?
5. Has a new growth commenced in such places?

I received 38 answers in all from 33 districts covering nearly the whole of the Danish coastal waters. I give some extracts below, arranged according to the waters and with name and domicile of the informant.

Limfjorden. Nykøbing Mors (L. Christensen): The eel-grass has disappeared everywhere along the coasts and on the shoals in the district. It began to disappear in April and May 1933. The fishermen think that some disease has caused the disappearance of the eel-grass. However, a new growth has commenced in several places.

Struer (P. Petersen): The eel-grass has disappeared everywhere in the district where it was formerly found in large quantities. It grew dark and speckled in the top. A new growth occurs in several paces, but only in small quantities.

Thisted (J. P. Diget): The eel-grass disappeared everywhere in the autumn and winter of 1932. The new growth is but insignificant.

Aalborg (A. S. Thomsen): The eel-grass disappeared in the Hals—Aalborg area in March 1933. A new growth began in May, but disappeared once more after having attained a height of 25—30 cm.

Eastern coast of Jutland. Frederikshavn (K. Nielsen): In the coastal area from Hals to the Skaw, at Læsø, and on the bars in the Kattegat from Dvalegrundene and southwards the eel-grass has disappeared. In 1922 it disappeared in one locality (Asaa); along the rest of the coast it began to disappear in August 1932 and has not yet reappeared. Only a very insignificant new growth.

The Mariager Fjord (A. S. Larsen)
The Randers Fjord (C. Skaaning)
} The eel-grass has disappeared in the outer but not in the inner part of the fjord.

Grenaa (M. Madsen): The eel-grass has disappeared on the shoal "Tangen" and along the coast, presumably in the autumn or winter of 1932—33.

Aarhus (O. Nørgaard): The eel-grass has disappeared everywhere in the district during the spring of 1933. A new growth was observed but has disappeared again.

Samsø. Langøre (Fr. Petersen): The eel-grass has disappeared from Samsø, only some few sparsely covered areas are left. The wasting began in April—May 1933 and reached its highest in June and July of the same year. At some few places in the inner part of the fjord there is apparently a new growth.

Funen. Bogense (E. Bach Jørgensen): The eel-grass is gone everywhere in the district. Its growth was rather vigorous until the end of the winter 1932—33, but in March and April of 1933 it fell and remained lying on the bottom where it putrefied. Old fishermen say that they have never experienced a complete disappearance of the eel-grass from so large areas as this year. An insignificant new growth has been observed, especially in the shallow water at the coast.

Odense, outer Fjord (P. A. Johansen): The decrease of the eel-grass began already in October 1932, and in the spring of 1933 nothing was left in the whole of the Fjord. New growth insignificant.

Odense, inner Fjord. Stige (J. M. Jensen): All the eel-grass disappeared about July, 1st. No new growth observed.

Kerteminde: From the beginning of June the eel-grass disappeared nearly everywhere.

Nyborg (K. A. Larsen): A disappearance of the eel-grass has been noticed in the Nyborg Fjord and at the coast S. of this place, except, however, the areas inside the 1-m curve. Otherwise nothing unusual has been observed.

Svendborg (H. M. Jensen): Although the beds of eel-grass have been very thin this year, nothing unusual has been observed.

Faaborg (J. H. Jørgensen): Nothing unusual has been observed.

South Jutland. Aabenraa (J. M. Jensen): From the earliest spring months of 1933 the northern part of the district in the water round Aarø is depleted of eel-grass; a new growth disappeared when the leaves were a few cm. long. In the southern part of the district nothing unusual.

Zealand. Kalundborg (H. Høj): The eel-grass was fresh and green throughout the summer.

Havnsø (Chr. Larsen): The beds of eel-grass at Nexelø have been decreasing year by year throughout a long period. Otherwise nothing worthy of noting.

Lynæs (H. I. Frederiksen): The beds of eel-grass in the Isefjord were small in spring, but a new growth came in June—July, so that now there is eel-grass everywhere in the shallow water.

Holbæk (N. S. Jensen): This year the eel-grass is very thin; a sparse growth has commenced; otherwise nothing of interest.

The Sound (Copenhagen, F. Jensen): The eel-grass of a normal appearance.

Karrebæksminde (Bagger Jensen): Nothing unusual to be seen.

Masnedsund (Chr. Th. Larsen): There is a rich growth of eel-grass everywhere in the district.

Nakskov (Jul. Juul): The beds of eel-grass have diminished gradually through these late years; apart from this nothing unusual has been noticed.

Bornholm. Rønne (J. H. Hansen): The eel-grass is very infrequent at Bornholm, and no change or disease has been observed.

From the Danish Biological Station investigations of the beds have been made in many different localities. Everywhere the same symptoms were met with: dark specks appeared on the leaves spreading more and more; at last the leaves grew black and sank to the bottom; also the rhizomes grew black and died away. So I realized that the disease had now reached our waters. But it appears from the above that as late as Sep. 1st, 1933 J. M. Jensen, Head Assistant of Aabenraa reported that the disappearance of the eel-grass only goes as far as the water round Aarø. In August 1933 the Fishery Assistants of Kalundborg, Lynæs (Isefjord), the Sound, Karrebæksminde, Svendborg, and Faaborg could still report the *Zostera* of their districts to be fresh and green. The map in Fig. 1 presents the situation about Sep. 1st, 1933. — However, a closer examination of the eel-grass of the Sound (Nivaa-Bugten) on Sep. 11th, 1933 showed that many of the leaves, although apparently fresh, had already been affected by the disease, and the same thing was observed in the eel-grass of Svendborg Sound on Oct. 7th, 1933 and later on in the *Zostera* of Nyborg Fjord. So it is no doubt only a matter of time when the disease will also get the better of the eel-grass areas of all our southern waters.

In several of the reports it is emphasized that the disease will first attack the latifolious *Zostera*, growing in deeper water and soft bottom; to all appearance the narrow-leaved form growing in shallower water and hard bottom makes a better stand against the attack. It is further characteristic that the disease has followed the currents of the open waters. Thus the eel-grass beds along the main fairways of the Limfjord succumbed already in the winter 1932—33 and the spring of 1933 whereas the eel-grass of the out-of-the-way fjords with trifling currents, as e. g. the Skive Fjord, was fresh and green until the beginning of August 1933.

So there is hardly any doubt that an epidemic disease has reached the Danish eel-grass beds with the northgoing current along the western coast of Jutland, and the *facies morbi* being everywhere the same as is described in France and Holland there is hardly any doubt either that it is the same disease.

By my request Dr. Henning E. Petersen of the Botanical Laboratory of Copenhagen has undertaken to make a closer study of the disease. In the plants attacked he found a fungus, which branched like a network in the interior of the tissue. He managed to cultivate a similar fungus, which was able to infect fresh *Zostera*-leaves and produce the characteristic specks on them. The fungus will bear a salinity of

Fig. 1. Map showing the chief eel-grass areas along the Danish coasts on Sep. 1st, 1933. The hatched areas denote places where the eel-grass beds have been wasted, the dotted areas show places where there is still fresh and green *Zostera*. The map is based partly on information given by the staff of the Fishery Patrol, partly on my own investigations.

more than 5 per cent., but further experiments are necessary for the purpose of ascertaining whether this fungus is really the cause of the disease ("Nature" 30-XII-1933).

Of the rather considerable literature on the disease already published in various countries should be emphasized a "Preliminary Remark on a Bacterial Disease in *Zostera*" by the French authors Fischer-Piette, Heim, and Lami, which appeared in Dec. 1932. The disease arose in the winter of 1931—32, and at the time in question it had spread over nearly the whole Atlantic coast of France whereas the Mediterranean coast had not yet been infected.

Strange to say the small *Zostera*-species *Z. nana*, which grows in the same places as *Z. marina*, is apparently not attacked by the disease. In the paper mentioned above it is maintained that a *bacillus*, which is supposed to be the cause of the disease, has been found in the diseased plants. The author concludes, "The attack having been known in North America for at least 2 years and in Europe only less than one year it is permissible to believe that this pathogene is of American origin." In Holland a report from Dina Spierenburg: A Disease in the Eel-grass, was published in May 1933. It appears from this report that the *Zostera* was wasted in the summer of 1932. The author quotes from the said French paper but expresses her doubt that the bacteria found are really the cause of the disease. According to a later communication (Jan. 1934) to me from Dr. Havinga a Dutch botanist and phyto-pathologist has made the diseased *Zostera* the object of an investigation; he found bacteria, but was not able to establish their being pathogenous.

It was touched on above that also in North America a similar disease appeared in the eel-grass areas as early as 1930. It is seen by reports from H. F. Lewis (1932), A. G. Huntsman (1932), and Clarence Cottam (1933) that the disease is supposed to have started at Virginia in 1930 whence it spread northwards to Cape Breton and Northumberland Strait in 1931 and wasted so large areas of *Zostera*, that the wild geese, which to some extent live on the rhizomes of this plant, went short of food, grew lean and came closer to the coast than they use to do. The symptoms of the disease are so exactly like those known from the European waters, that it is a most probable conclusion that Europe got this unpleasant disease from America.

According to E. I. Allen a disappearance of the eel-grass in England was observed in several localities at Devonshire in 1932; at the old swannery of Abbotsbury the *Zostera* disappeared completely. During 1933 the wasting spread, and in "Nature" of 19-VIII-33 it is reported by A. D. Cotton that also the area of the Thames estuary has now been attacked.

Also at the coasts of Norway and Sweden did the disease appear during the year 1933. According to a verbal communication given to me by Mr. P. Bjerkan, Fishery Adviser, Bergen, the eel-grass disappeared at the south-western coast of Norway early in the year already. In Sweden Dr. A. R. Molander (1933) and Prof. E. Lönnberg (1933) found that in the summer of 1933 great parts of the skerries at Bohuslän were completely void of *Zostera* in places (i. a. at the Zoological Station of Kristineberg) where there used to be luxuriant green beds of it. Prof. Lönnberg thinks that the disease has arisen early in the winter of the same year; he further considers the contagium to be of American origin and supposes that it has spread to South Europe and thence to Denmark and Sweden with the "southern bank water", which is pressed vigorously into our waters, carrying along organic life of many kinds like fish of southern origin and plankton organisms, which otherwise do not belong to our usual fauna, etc. This accounts for the fact that the disease has found a difficulty in reaching the southern parts of our waters, for the outgoing "Baltic" current of rather fresh water counter-acts the indrift of foreign organisms. It is true that there is mostly a salt inward-bent current through the deep channels of the Sound and the Belts, but in the shallow places where the *Zostera* grows the Baltic current predominates.

Considering what is at present known about the course of the disease it seems very likely that the hypothesis on the spreading of the pathogene is correct. There is hardly any doubt that the disease which appeared at America is identical with that of the European waters. In this connexion it is interesting to note that according to H. F. Lewis (1932) Dr. E. Silver Dowding found "a coarse mycelium" in a black rhizome of *Zostera* in U.S.A.; however, it was not to be found in other specimens examined, and so it was considered out of question that this fungus could be the cause of the disease. On the other hand the fact that Dr. H. E. Petersen found a fungic mycelium in all the diseased plants from Danish waters seems to indicate the possibility that this is the very cause of the disease both in U.S.A.

and in Europe. It is to be hoped that later investigations will throw a light on this question.

As to the damage that has been caused and no doubt will be caused by the disease of the eel-grass the attention is in the first place fixed on the fact that the animals of the coastal regions are deprived of their food and shelter. Already in June 1933 the "Dansk Fiskeritidende" told about the failure of the prawn season on account of the wasting of the bottom vegetation; by the bye the same article says that on account of the same conditions the wild geese disappeared already during the month of April. More difficult to establish is the damage done to the small bottom animals of deeper water by the failure of the food supply from the coastal eel-grass beds; most likely this fact will be of no great importance. However, the enormous quantities of dead sea-weed on the bottom along our coasts have been a great nuisance to the eel fishery because they have prevented the use of the eel-seine in many places.

The stock of eel in itself does not seem to have suffered directly from the disappearance of the *Zostera*. In most cases the eel have probably migrated to the soft bottom outside the zone of the sea-weed where the hook fishery has often been profitable. The belief among fishermen that the disease of the eel-grass should be connected with the "Red Disease" in eel, has no foundation in fact; the latter has been known for many years in this country. It appears especially in hot summers.

Of course great damage has been done by the fact that the eel-grass can no longer be gathered for insulating and upholstering purposes, manure, etc. In Holland where large factories prepare the eel-grass, this industry has suffered a great loss.

Unfortunately we have no remedies against the disease in question. On the other hand conditions abroad seem to hold out some prospects that during the summer of 1934 the *Zostera* beds will recover in many of the places where they have now been wasted. In a letter dated Jan. 8th, 1934, e. g., Dr. B. Havinga writes that "in Holland the *Zostera* vegetation seems to reappear. During the summer of 1933, and especially during the latter part of the season prospects have constantly been brightening". Thus, although conditions cannot be expected to be normal in this country during the summer of 1934 we may hope, at any rate, that this will be the case during the summer of 1935.

I wish to express my sincerest thanks to the staff of the Fishery Patrol and especially to the Fishery Inspectors Trolle Thomsen and A. Jørgensen, who have assisted in an excellent manner during my work in this matter. My thanks are also due to Dr. H. E. Petersen for his cooperation and for his extensive work in studying the nature and cause of the disease.

March, 1934. *H. Blegvad.*

Literature cited.

1908. Ostenfeld, C. H.: On the Ecology and Distribution of the Grass-Wrack (*Zostera marina*) in Danish Waters. From the Danish Biological Station XVI.

1913. Petersen, C. G. Joh.: Om Bændeltangens (*Zostera marina*) Aars-Produktion i de danske Farvande. Mindeskrift for Japetus Steenstrup.

1932. Huntsman, A. G.: Disease in Eel Grass. Progress Reports of Atlantic Biological Station and Fisheries Exp. Station. No. 5. Oct. 1932.

1932. Lewis, H. F.: The Eel-grass Situation on the Atlantic Coast. Report from the Chief Federal Migratory Bird Officer, Ontario and Quebec, National Parks of Canada, Dept. of the Interior.

1932. Lami, Rob.: Fréquence de quelques algues marines dans la région Malouine en 1932. Bull. du Lab. Mar. à Saint-Servan. Fasc. X, p. 17, Sept. 1932.

1932. Fisher-Piette, E., Heim, R. et Lami, R.: Note préliminaire sur une maladie bactérienne des Zostères. Comptes rendus d. séances de l'Acad. des Sciences. T. 195, p. 1420, Dec. 1932.

1933. Heim, R. et Lami, R.: La maladie bactérienne des Zostères. Extension et causes favorisantes. Acad. d'Agriculture de France. 14. Juin 1933.

1933. Cottam, Clarence: Report to the Plant Disease Reporter of the U. S. Dept. of Agriculture. June 1933.

1933. Spierenburg, Dina: Een Ziekte in het Zeegras (*Zostera marina* L.). Tijdschrift over Plantenziekten. Vol. XXXIX, 8e afl., May 1933.

1933. »Mislykket Rejesæson«. Dansk Fiskeritidende, Nr. 26, 28. June 1933.

1933. »Tangsygdommen i Limfjorden«. Dansk Fiskeritidende. Nr. 32. 9. Aug. 1933.

1933. Cotton, A. D.: Disappearance of *Zostera marina*. Nature, 19. Aug. 1933.

1933. Blegvad, H.: Sygdommen i Bændeltangen. Dansk Fiskeritidende Nr. 34, 23. Aug. 1933.

1933. Blegvad, H.: En epidemisk Sjukdom på bandtången (*Zostera marina*). Ny svensk Fiskeritidsskrift. Nr. 18, 15. Sept. 1933.

1933. Molander, A. R.: Anteckningar till Zosteravegetationens förekomst vid västkusten. Ny svensk Fiskeritidsskrift, Nr. 18, 15. Sept. 1933.

1933. Lönnberg, E. and Gustafson, G.: Från Kristinebergs Zoologiska station sommaren 1933. Fauna och Flora. Häft 5, p. 193.

1933. Petersen, Henning E.: Wasting Disease of Eelgrass (*Zostera marina*). Nature 3348, 30. Dec. 1933.

Transplantations of Plaice from the North Sea to the Belt Sea 1928—1933.

The Scientific Survey.

By

H. BLEGVAD

CONTENTS

Page

Introduction 11
I. Distribution, size and age of the plaice transplanted 12
A. Division of the waters into areas of transplantation 12
B. Quantity and number of plaice transplanted during the years 1928—1933 13
C. Size and weight of the plaice transplanted 15
D. Age of the plaice transplanted 17
II. The markings 21
A. Methodics 21
B. The recaptures 23
a. The vitality of the marked fish 25
b. The fishing intensity 27
c. The recaptures of the different months 27
d. How many of the fish transplanted are caught by foreign fishermen? 30
C. The migrations 30
a. The migrations from the individual places of liberation 30
b. Does any difference exist between the migrations of the transplanted plaice and the local ones? 55
c. The long migrations 58
d. The numerical distribution of males and females in the recaptures. Are the migrations of males and females equally extensive? 59
e. The seasonal migrations to shallower and deeper water 61
f. Do the plaice transplanted breed in the area of transplantation? 62
D. The growth of the marked plaice 67
a. The growth of the plaice transplanted as compared with the growth of the local stock 67
b. The growth of the plaice in the different years 68
1. The growth of the plaice transplanted 68
2. The growth of the local plaice 70
c. The growth of the plaice in the various areas of transplantation 70
III. The profitableness of the transplantations 73
A. The profitableness of the transplantations as calculated by the percentage recaptures of marked fish 73
B. The yield of the transplantations as calculated by analyses of the catches of fishermen 75
IV. Are small or large plaice, young or old plaice to be preferred as objects of transplantation? 81
V. Future transplantations 82
VI. Summary 83
List of Literature 84

Introduction.

In the "Report of the Danish Biological Station", No. XXXVII, 1932, the author has published a "Preliminary Report on the Danish Experimental Transplantations of Plaice From the North Sea to the Belt Sea During the Years 1928—1931" (H. Blegvad, **1932**). The paper contains an account of the conditions of the transplantations to the Belt Sea[1]), their accomplishment and their results up to and including the year 1931. In "Journal du Conseil international pour l'exploration de la mer" Vol. VIII, No. 2, 1933 (H. Blegvad, **1933**) a general review on "Transplantations of Plaice" further accounts for the quantities transplanted in the years down to 1933 inclusive, and contains a brief report on the practical results achieved.

The appreciation of the practical results of the transplantations is based on the scientific survey, which has been carried out every year. However, none of the papers mentioned above comments on this survey, although the latter, as has been said, was used as a basis for estimating on the benefit that is derived from the transplantations by the fishery. The following is a more elaborate statement of the scientific survey and of its results. Firstly, it comprehends the distribution, size, weight, and age of the transplanted plaice, secondly, the markings of both transplanted North Sea fish and local Belt Sea fish, and, thirdly, race- and age-analyses, carried out mainly to establish how great a part of the captures of the fishermen originates from fish transplanted.

After the transplantations of 5 years (1928, 1929, 1931, 1932, and 1933) had been carried out in an experimental way, they were continued in 1934 within the same scope and with the usual Government grant (50 000 Kr.). But the areas of transplantation have been extended to comprise the southern Kattegat, too, and less expensive offers of the supplying of fish for the transplantations have been obtained from the same firm (L. Rønn at Esbjerg) which in all the previous years has procured the plaice for transplantations and which, therefore, has in course of time gathered great experience in this field. Consequently it has been possible with the same grant to transplant a larger quantity of plaice in 1934 than during former years.

The conditions of the supplying of plaice for the transplantations of 1934 were the same as in the previous years. They are quoted below because in a summing-up they will give the gist of the matter.

1. For the transplantation of plaice to the Belt Sea, the southern Kattegat, the Isefjord, and the Sound during the spring of 1934 it is intended to use a quantity of abt. 120 000 Kg. The fish must be caught in the North Sea and be landed at Esbjerg, and before they are carried overland to Fredericia, they are to be kept in well-boxes for at least 48 hours. The transport from Esbjerg to Fredericia is to be carried out in closed fish-lorries.
2. The plaice to be transplanted must be sized 170—250 mm. total length.
3. At Fredericia the fish are kept in well-boxes for at least 48 hours before they are carried to the positions of liberation.
4. The period of storage will be controlled both at Esbjerg and at Fredericia, and the supervisor will take action if terms are not observed.

[1]) Here and in the following the term "Belt Sea" includes: the Samsø Belt, the Great and Little Belt, the western Baltic, the Isefjord and the Sound.

5. Special care must be taken of the transport from Fredericia to the places of liberation being carried out by well-smacks of at least 20 tons gross and of the loads being far lighter than the normal loads of living fish. The maximum loads of these big well-smacks is fixed at 2 000—2 500 Kg. as estimated by the Fisheries Inspectorate. Additional quantities will be put out without compensation together with the rest of the load.
6. When the fish are delivered at the places of liberation the contract price will only be paid for fish that are considered to be absolutely likely to live. If the Inspector of Fisheries, or the person who receives the fish on behalf of the supervisor, thinks that part of the fish is not likely to live, the price of the whole load will be reduced by the estimate of the supervisor.
7. The liberation of the fish is reckoned to commence at the beginning of April and to be finished before the end of the same month.

The 120 000 Kg. of fish are intended to be distributed in the following way:

The northwestern Belt Sea	27 000 Kg.
The Little Belt	21 000 -
The water round Ærø	10 000 -
The "Smaalandsfarvand"	10 000 -
The Great Belt	29 500 -
East of Samsø	5 000 -
The Isefjord with "Grønne Revle"	5 000 -
The Sound	5 000 -
The southwestern Kattegat	7 500 -

The fishermen are still vividly interested in the transplantations, which among other things has manifested itself in the fact that one of the Fishermen's Associations (Bagenkop, Langeland) in 1934 granted a rather considerable sum of money (2 000 Kr.) for the purpose of having an additional transplantation carried out inside the area of the Association. This sum of money was collected by the fishermen themselves, who delivered a fixed percentage of what they earned (in gross) in selling their catches.

The following will show that in spite of many difficulties these transplantations have been giving entire satisfaction throughout a series of years, and none the less because a vivid interest in the experiments was always displayed by the Fisheries Inspectorate. F. V. Mortensen, Director of Fisheries as well as C. Trolle Thomsen and A. Jørgensen, Inspectors of Fisheries, and their staff have carried out a great and excellent work for the benefit of the whole matter; it should be specially emphasized that C. Trolle Thomsen, Inspector of Fisheries, has organized the transports to the places of liberation and the control of the liberations in an excellent way. I beg to render my best thanks to these gentlemen for good collaboration throughout the years.

The scientific survey was carried out exclusively by the Danish Biological Station, partly onboard the "Biologen", the research vessel of the Station, partly onboard the boats of the Fisheries Inspectorate or the well-smacks. I take the opportunity of thanking my Assistants, Dr. phil. E. M. Poulsen and Cand. S. W. Fogh for their valuable assistance, which made it possible to carry out the comprehensive investigations in spite of many extrinsic difficulties.

During the preparation of the present report the Assistants of the Biological Station, Cand. S. W. Fogh, Dr. Å. J. C. Jensen and Dr. E. M. Poulsen and further Miss H. Stuhlmann, Stud. mag. J. Krause and L. P. Larsen, the Mate, have assisted me in an excellent way in working up tables, graphs, charts, etc.—V. Pedersen, Chief Draftsman, has most carefully carried out all charts and diagrams reproduced in this paper. I beg to render my best thanks to all these collaborators of mine.

I. Distribution, Size and Age of the Plaice Transplanted.

A. Division of the waters into areas of transplantation.

Since the introductory transplantations to the Belt Sea waters in 1928 a fixed plan of action, with small modifications suggested by experience, has been followed throughout the years. As a matter of consequence the scientific survey has achieved results, which for each separate locality can be compared from one year to another.

The selecting of the localities of transplantation has always been directed by the principal point of view that the fish should be liberated in places

where, either by a prohibition of seine fishing or in other ways, they could most likely be protected against been caught too early, that is to say before they had attained a profitable size and weight. Besides, it was duly considered that the plaice should

bounds of the waters as represented on the chart Figure 1; here are also given the names of the waters, shallows, land, and islands that are frequently used in the present paper.

To the areas IX and X plaice were only trans-

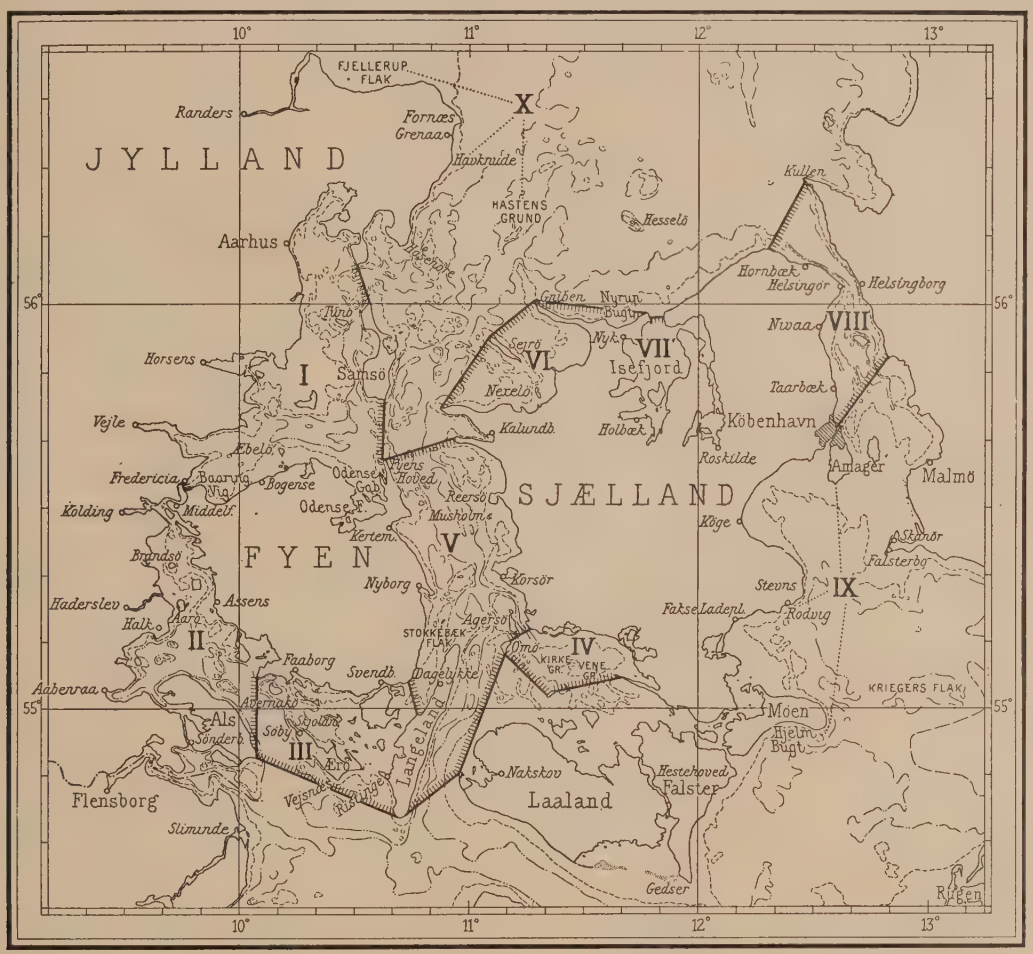


Figure 1. The areas of transplantation, I—X.

not be liberated in localities where the hydrographic conditions and the sea-bottom were too different from the places in which they had been captured.

The whole area of transplantation covers waters of a rather heterogeneous character, and so it has been divided into 10 different areas by the natural

planted in 1928, because it appeared from the investigations carried out that a repetition of the experiments in these areas would most probably meet with an unsatisfactory result. In the following we shall therefore principally consider the material from the areas I—VIII.

B. Quantity and number of plaice transplanted during the years 1928—1933.

During the years 1928—1933 a total of 550 300 Kg. of plaice, representing a number of a little more than

6 million individuals, were transplanted from the North Sea to the Belt Sea waters. The chart Figure 2

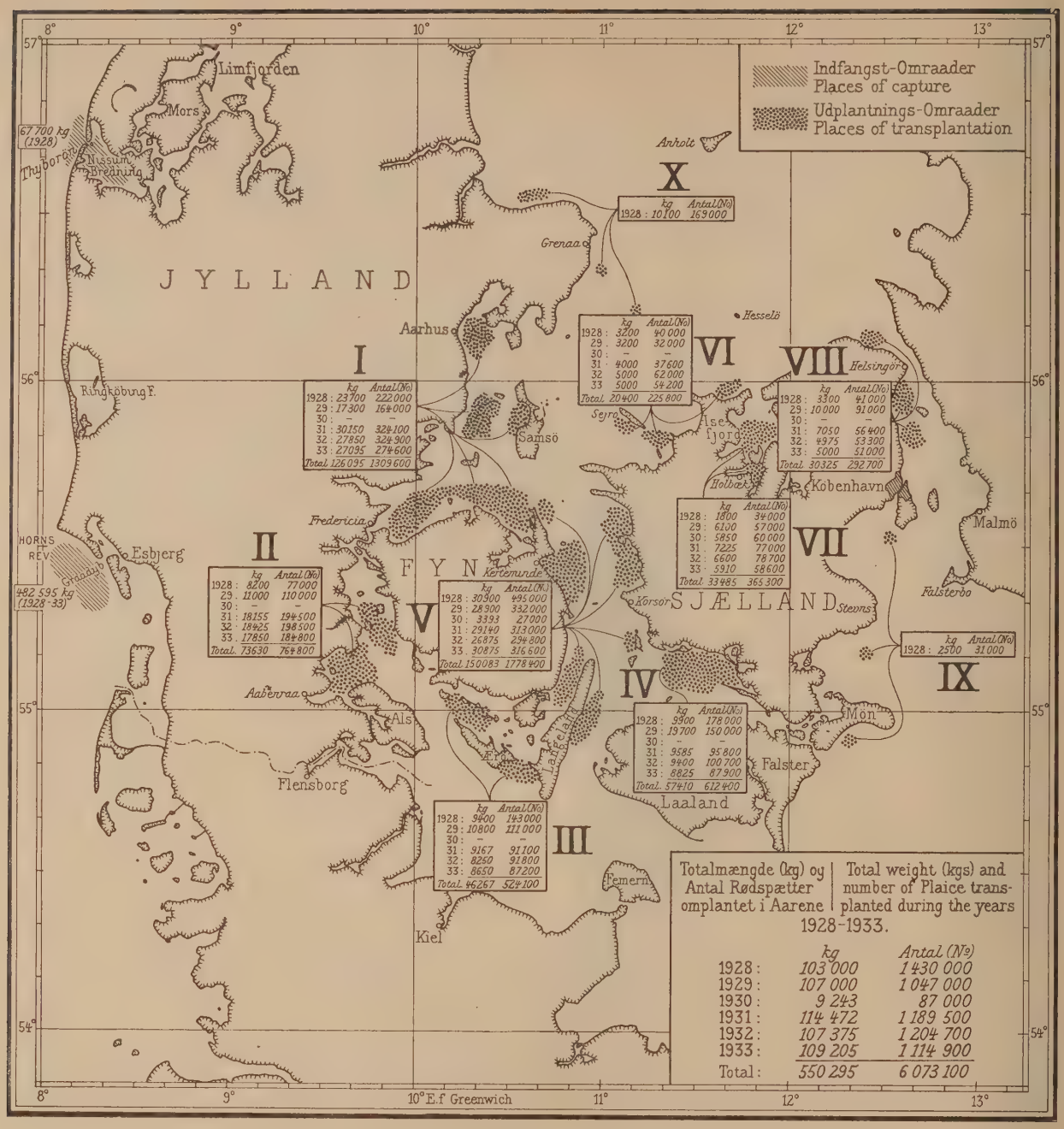


Figure 2.

shows the quantities and numbers of plaice transplanted each year in the different areas of transplantation.

As will appear from the chart by far the greater part of the plaice transplanted, viz. 482 600 Kg., originates from the Horns Reef area at Esbjerg. Only in 1928 most of the plaice were caught in the waters on both sides of the Thyborøn Kanal and were carried by well-boats through the Limfjord to the transplantation areas. In this year a total of 103 000 Kg. or abt. 1 430 000 individuals were transplanted. These fish were caught in the following places:

The water inside the Thyborøn (the Nissum Broad)	39 200 Kg.	743 000 ind.
The water outside the Thyborøn..	28 500 -	356 000 —
The Horns Reef area (at Esbjerg)..	35 300 -	331 000 —

In other words two thirds of the weight quantity of the fish transplanted originated from the waters at Thyborøn. During the following years the plaice for the transplantations were taken exclusively from the Horns Reef area at Esbjerg. The reason why the plaice were no longer taken from the Thyborøn was, as mentioned by the present author (**1932**, p. 86), partly, that the Esbjerg plaice seemed to be as able to survive as those from the Thyborøn although they were carried in lorries from Esbjerg to Fredericia, partly, that the way of transport to the places of liberation was longer from the Thyborøn than from Esbjerg. The latter fact was of special importance, the Thyborøn fish, especially those originating from the Nissum Broad, being smaller than the Esbjerg fish and therefore less resistant during a long transport.

Table 1.

Area	Year	Kg.	Individuals
I. The water between Samsø, Jutland, and Funen	1928—33	126 095	1 309 600
II. The southern Little Belt	—	73 630	764 800
III. The water round Ærø	—	46 267	524 100
IV. Smaalandshavet	—	57 410	612 400
V. The Great Belt and the Langelands-Belt	—	150 083	1 778 400
VI. N. W. of Seeland....	—	20 400	225 800
VII. The Isefjord.....	—	33 485	365 300
VIII. The Sound.....	—	30 325	292 700
IX. E. of Seeland	1928	2 500	31 000
X. The southwestern Kattegat.....	—	10 100	169 000
	Total...	550 295	6 073 100

On an average somewhat more than 100 000 Kg. of plaice were transplanted every year except in the year 1930 when it was considered desirable to collect all material of the previous years, especially the results of the markings, before the experiments were carried further on. However, the two Fishermen's Associations of Isefjord and Kerteminde had themselves collected the money for a transplantation to their respective waters; they received a Government grant, so that two small, local transplantations might be carried out in 1930. A total of 9 243 Kg. or abt. 87 000 individuals were transplanted.

The total quantities of North Sea plaice liberated in the different areas of transplantation down to and including the year 1933 are put down in Table 1.

It will be seen that the transplantation areas V, I, and II — the Great Belt, the water between Samsø, Jutland, and Funen, and the southern part of the Little Belt — have had more than half the quantity of fish transplanted, while the more remote areas have got smaller shares. It was already touched on that in the areas IX and X — east of Seeland and south of Møen and in the southwestern Kattegat — plaice were only transplanted in 1928.

In each of the years the following quantities were transplanted:

Year	Kg.	Individuals
1928	103 000	1 430 000
1929	107 000	1 047 000
1930	9 243	87 000
1931	114 472	1 189 500
1932	107 375	1 204 700
1933	109 205	1 114 900
Total...	550 295	6 073 100

As will appear from the figures above a quantity of fully 100 000 Kg. of plaice or — calculated in numbers — more than 1 mill. plaice have been transplanted annually, except in the year 1930.

C. Size and weight of the plaice transplanted.

During the transplantations several samples of the loads of the boats were measured in order to establish the size of the fish to be transplanted. Experience shows that fish below a certain size are very susceptible of the rather rough handling, to which the transplantation fish must necessarily be subjected: fishing, sorting, keeping in well-boxes, and transport. As appears from the above mentioned contract it is formally requested that the fish to be transplanted must be sized 17—25 cm. In the places, however, where the fish to be transplanted are captured, the average length of the stock of plaice varies from year to year, and so we have in reality to include fish the size of which touches the extremities stipulated. In the years 1928—1933 only about 6.5 % of the fish transplanted from the Horns

Table 2. Samples of liberated plaice, measured and weighed during the transplantations of 1928—33.

Length in cm.	1928 Thyborøn fish	1928 Horns Reef fish	1929 Horns Reef fish	1930 Horns Reef fish	1931 Horns Reef fish	1932 Horns Reef fish	1933 Horns Reef fish	Total Horns Reef fish
10	**15**	..	..	..	..	..	..	..
11	**59**	..	..	..	..	..	..	..
12	**117**	..	..	..	10	..	..	**10**
13	**194**	1	7	..	35	2	..	**45**
14	**298**	4	17	..	88	8	..	**117**
15	**515**	13	27	..	110	35	6	**191**
16	**678**	49	43	..	159	127	19	**397**
17	**672**	79	79	2	185	291	37	**673**
18	**443**	94	163	6	236	447	106	**1052**
19	**328**	137	346	3	425	632	236	**1779**
20	**204**	178	590	10	615	568	378	**2339**
21	**149**	184	1053	14	917	511	506	**3185**
22	**160**	209	1262	30	1048	388	513	**3450**
23	**122**	290	898	42	1001	290	424	**2945**
24	**89**	343	392	44	574	130	261	**1744**
25	**45**	240	80	38	265	45	115	**783**
26	**16**	133	27	17	88	18	29	**312**
27	**4**	77	5	2	27	5	9	**125**
28	**3**	25	3	2	7	1	2	**40**
29	**4**	18	..	..	..	..	..	**18**
30	**1**	4	..	..	..	..	..	**4**
31	..	1	..	..	..	..	..	**1**
32	..	1	..	..	..	..	..	**1**
Total...	**4116**	2080	4992	210	5790	3498	2641	**19 211**
Average length in cm.[1])	**17.17**	22.38	21.42	23.22	21.14	19.97	21.52	**21.23**
Weight per score in Kg.	**1.23**	2.13	2.04	2.38	1.92	1.78	1.96	**1.94**

[1]) + 0.5 cm. to all figures.

Reef Area fall outside the measures 17—25 cm., whereas the considerably smaller Limfjord fish of 1928 exceed the margins by 46.3 %.

Table 2 gives the total lengths[2]) and weights of all the plaice that were examined during the transplantations of 1928—33, a total of 19 211 individuals.

It is plainly to be seen that the average size and weight of the individuals varies highly from year to year. As regards the year 1928 the measurements include plaice from both the Thyborøn area and the Horns Reef area; it is evident that the former are considerably smaller than the latter (see p. 15), the average length of the 4 116 individuals from the Thyborøn being more than 5 cm. below that of the 2 080 plaice from the Horns Reef. Correspondingly, the weight per score of the Thyborøn fish was only 1.23 Kg. while the Horns Reef fish weighed 2.13 Kg.

[2]) By international practice all lengths have been measured to the nearest cm. below, and so 0.5 cm. should properly be added to the average lengths, but in cases where the material was used only for comparisons such additions have not been carried out here and in the following.

Taking each year separately we get the following survey of the average size and weight of the fish transplanted:

Horns Reef fish	1928	1929	1930	1931	1932	1933	All years
Average length in cm.	22.38	21.42	23.22	21.14	19.97	21.52	21.23
Weight per score in Kg.	2.13	2.04	2.38	1.92	1.78	1.96	1.94

Thyborøn fish	1928
Average length in cm.	17.17
Weigth per score in Kg.	1.23

As regards the Thyborøn fish it should be noticed that there is an obvious difference in the size of the plaice from outside and from inside the Kanal, the former being larger than the latter. As an instance may be mentioned that during the transplantations to the Limfjord in April 1934 a sample of 143 plaice captured outside the Thyborøn were measured to have an average length of 22.73 cm., while a sample

of 155 plaice taken inside the Kanal in the Nissum Broad averaged only 17.66 cm. As mentioned on p. 15 the plaice taken at the Thyborøn for the transplantation to the Belt Sea in 1928 were captured mainly inside the Kanal in the Nissum Broad; hence the small size of the fish.

D. Age of the plaice transplanted.

In order to investigate the age-composition of the stock of plaice that was transplanted a great many age-analyses of the fish were made every year. All determinations of age were made by means of the otoliths.

Table 3. Age-composition.
Thyborøn fish transplanted in 1928.

Age-group	I-Gr.	II-Gr.	III-Gr.	IV-Gr.	V-Gr.	Total
Year-class	1927	1926	1925	1924	1923	
cm.						
10	..	3	..	..	..	3
11	1	9	..	..	..	10
12	..	20	2	..	..	22
13	..	11	9	..	..	20
14	..	4	44	..	..	48
15	..	12	57	..	..	69
16	..	6	89	..	..	95
17	..	6	75	1	..	82
18	..	2	60	2	..	64
19	..	3	30	2	..	35
20	..	..	17	2	..	19
21	..	2	10	1	..	13
22	..	..	7	3	..	10
23	..	..	4	5	1	10
24	..	..	7	2	1	10
25	..	..	6	..	..	6
26	..	..	4	3	2	9
27	..	..	..	2	1	3
28	..	..	1	..	..	1
29	..	..	..	2	1	3
Total	1	78	422	25	6	532
%	0.2	14.7	79.3	4.7	1.1	100
Average length in cm.	(11)	13.76	17.08	(22.84)	(25.83)	16.99

The brackets denote that the figures are less reliable on account of too small a material.

Tables 3 and 4 represent the grouping as regards the age of respectively the Thyborøn fish from 1928 and the Horns Reef fish from the years 1928—1933; 5 746 individuals in all were examined[1]).

It is evident that the Thyborøn fish are considerably younger than the fish from the Horns Reef. A comparison between the principal facts of both tables gives the following survey.

[1]) All measurings and age-determinations mentioned here being carried out in the month of April the I-Group corresponds fairly well to the one-year-old fish, the II-Group to the two-years-old fish, etc.

Age-group	Number of individuals T.	Number of individuals H.R.	Number given in % T.	Number given in % H.R.	Average length in cm. T.	Average length in cm. H.R.
I-Gr.	1	..	0.2	..	(11.0)	..
II-Gr.	78	99	14.7	1.9	13.76	15.69
III-Gr.	422	1034	79.3	19.8	17.08	19.09
IV-Gr.	25	2810	4.7	53.9	(22.84)	21.56
V-Gr.	6	1100	1.1	21.1	(25.83)	22.43
VI-Gr.	..	166	..	3.2	..	24.68
VII-Gr.	..	5	..	0.1	..	(26.00)

T. = plaice captured at the Thyborøn in 1928.
H. R. = — — — Horns Reef in 1928—33.

The brackets denote that the figures in question are less reliable because they are based on a comparatively small number of individuals. It appears by this comparison that while the III-Gr. was prevalent in the Thyborøn fish of 1928, the IV-Gr. predominated in the plaice from the Horns Reef area throughout the years 1928—1933; further, that no less than 94 % of the Thyborøn fish were 3 years

Table 4. Age-composition.
Horns Reef fish transplanted in 1928—33.

Length in cm.	II-Gr. No. of ind.	III-Gr. No. of ind.	IV-Gr. No. of ind.	V-Gr. No. of ind.	VI-Gr. No. of ind.	VII-Gr. No. of ind.	II—VII-Gr. No. of ind.
12	3	..	..	..	..	..	3
13	9	8	..	..	..	..	17
14	15	24	..	..	..	..	39
15	22	38	1	..	..	..	61
16	17	84	12	1	..	..	114
17	15	109	51	3	..	..	178
18	10	144	113	15	..	..	282
19	7	176	220	50	..	..	453
20	1	157	350	106	1	..	615
21	..	133	521	176	2	..	832
22	..	88	625	210	10	..	933
23	..	41	534	225	31	..	831
24	..	18	275	175	34	..	502
25	..	9	85	91	39	2	226
26	..	5	13	34	25	1	78
27	..	..	10	7	17	2	36
28	..	..	..	6	2	..	8
29	..	..	..	1	4	..	5
30	..	..	..	..	1	..	1
Total	99	1034	2810	1100	166	5	5214
%	1.9	19.8	53.9	21.1	3.2	0.1	100
Aver. length in cm.	15.69	19.09	21.56	22.43	24.68	(26.00)	21.24

Table 5. Plaice from the Horns Reef area.
Size and quantity of the individual age-groups in the different years of transplantation.

II-Group.

cm.	1928	1929	1930	1931	1932	1933	Total
12	..	..	..	3	..	..	3
13	1	1	0	7	..	..	9
14	..	2	..	13	..	..	15
15	1	10	..	7	2	2	22
16	5	7	..	3	2	..	17
17	5	5	..	4	..	1	15
18	2	5	..	2	..	1	10
19	4	..	..	2	1	..	7
20	1	..	..	..	..	..	1
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
Total	19	30	0	41	5	4	99
Aver. length in cm.	17.11	15.93	..	14.73	(16.20)	(16.25)	**15.69**

III-Group.

cm.	1928	1929	1930	1931	1932	1933	Total
13	..	..	..	8	..	..	8
14	..	..	..	22	2	..	24
15	..	1	..	31	6	..	38
16	6	2	..	49	23	4	84
17	14	16	1	51	22	5	109
18	14	15	4	71	28	12	144
19	19	17	3	115	17	5	176
20	30	18	1	97	8	3	157
21	12	17	1	95	4	4	133
22	16	17	1	50	3	1	88
23	15	6	1	18	..	1	41
24	9	4	..	5	..	..	18
25	7	1	..	1	..	..	9
26	5	..	..	..	..	..	5
Total	147	114	12	613	113	35	1034
Aver. length in cm.	20.52	19.84	19.33	18.90	17.67	18.54	**19.09**

IV-Group.

cm.	1928	1929	1930	1931	1932	1933	Total
15	..	..	..	..	1	..	1
16	..	..	..	..	8	4	12
17	..	4	..	1	42	4	51
18	1	7	..	6	76	23	113
19	2	34	..	33	119	32	220
20	6	102	4	112	96	30	350
21	10	177	3	219	87	25	521
22	20	223	9	293	61	19	625
23	19	138	7	311	43	16	534
24	15	58	5	176	9	12	275
25	8	11	7	52	4	3	85
26	1	4	..	6	2	..	13
27	2	..	..	8	..	..	10
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
Total	84	758	35	1217	548	168	2810
Aver. length in cm.	22.65	21.85	22.77	22.26	19.95	20.41	**21.56**

V-Group.

cm.	1928	1929	1930	1931	1932	1933	Total
15	..	..	..	..	..	..	..
16	..	..	..	..	..	1	1
17	..	..	..	..	..	3	3
18	..	..	..	..	1	14	15
19	2	..	..	..	3	45	50
20	1	..	1	..	5	99	106
21	3	1	1	6	5	160	176
22	3	5	5	12	9	176	210
23	12	4	13	34	15	147	225
24	21	4	14	27	11	98	175
25	16	..	10	21	4	40	91
26	7	..	8	12	4	3	34
27	3	..	1	..	..	3	7
28	2	..	1	2	..	1	6
29	1	..	..	..	..	..	1
Total	71	14	54	114	57	790	1100
Aver. length in cm.	24.65	22.79	24.06	23.80	22.65	21.9	**22.43**

VI-Group.

cm.	1928	1929	1930	1931	1932	1933	Total
20	1	..	..	..	..	..	1
21	2	..	..	..	..	..	2
22	3	..	1	4	..	2	10
23	12	..	..	5	2	12	31
24	18	1	1	6	..	8	34
25	20	1	..	7	..	11	39
26	16	1	..	2	..	6	25
27	9	..	..	5	..	3	17
28	1	..	..	1	..	..	2
29	4	..	..	..	..	..	4
30	1	..	..	..	..	..	1
Total	87	3	2	30	2	42	166
Aver. length in cm.	24.93	(25.00)	(23.00)	24.57	(23.00)	24.38	**24.68**

VII-Group.

cm.	1928	1929	1930	1931	1932	1933	Total
25	..	1	1	0	0	0	2
26	1	..	..	..	..	..	1
27	2	..	..	..	..	..	2
28	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
	..	..	..	..	..	..	..
Total	3	1	1	0	0	0	5
Aver. length in cm.	(26.67)	(25.00)	(25.00)	..	..	..	**26.00**

Table 6. The percentage distribution of age-groups in the plaice transplanted in the years 1928—33. Below the figures of percentage is given the average length in cm. of the age-group in question. The brackets denote that the said figures are less reliable.

	Year of transplantation	No. of individuals examined	I	II	III	IV	V	VI	VII	←Age-Group
Thyborøn fish	1928	532	0.2 (11.0)	14.7 13.76	79.3 17.08	4.7 (22.84)	1.1 (25.83)	.. ..	.. ..	.. ..
			1927	1926	1925	1924	1923	..	..	Year-class
Fish from the Horns Reef Area	1928—33	5214	.. ..	1.9 15.69	19.8 19.09	53.9 21.56	21.1 22.43	3.2 (24.68)	0.1 (26.00)	.. ..
	1928	411	.. ..	4.6 17.11	35.8 20.52	20.4 22.65	17.3 24.65	21.2 24.93	0.7 (26.67)	Year-class ↓
	1929	920	.. ..	3.3 15.93	12.4 19.84	82.4 21.85	1.5 22.79	0.3 (25.00)	0.1 (25.00)	1921
	1930	104	.. ..	.. ..	11.6 19.33	33.5 22.77	51.9 24.06	2.0 (23.00)	1.0 (25.00)	1922
	1931	2015	.. ..	2.0 14.73	30.4 18.90	60.4 22.26	5.7 23.80	1.5 24.57	.. ..	1923
	1932	725	.. ..	0.7 (16.20)	15.6 17.67	75.6 19.95	7.8 22.65	0.3 (23.00)	.. ..	1924
	1933	1039	.. ..	0.4 (16.25)	3.4 18.54	16.2 20.41	76.0 21.90	4.0 24.38	.. ..	1925
			Year-class:	1931	1930	1929	1928	1927		1926

old and less, the same age including only 22 % of the Horns Reef fish.

In calculating the average age we get 2.92 and 4.04 years for the Thyborøn fish and the Horns Reef fish, respectively; the average lengths are 16.99 and 21.24 cm., respectively. In other words: the Thyborøn fish were on an average more than 1 year younger and more than 4 cm. shorter than the Horns Reef fish.

The average lengths of the 2- and 3-years-old plaice show that the Horns Reef fish have been growing much more rapidly than the Thyborøn fish. The opposite might seem to be the case with the 4- and 5-year-old plaice, but here the material from the Thyborøn is too small to afford reliable figures for a comparison.

Table 5 gives all age-determinations, arranged according to age-groups, of fish transplanted from the Horns Reef area.

In viewing the size of the plaice of a single age-group we find no small variation from year to year. Table 6 was worked up for the purpose of illuminating this fact. It represents the percentage distribution (withing the total of plaice examined) of the age-groups of the successive years; below each figure is given the average length in cm. of the age-group in question, and the oblique lines, which connect the individual year-classes, are meant to facilitate the general view of things, so that each year-class may be followed throughout the years.

It is seen that the same age-group does not predominate every year — a state of things which has

formerly been demonstrated to exist in nearly all our waters (see for instance Å. J. C. Jensen **1931**, p. 9—10 and **1933**, p. 22, and H. Blegvad **1927**). The reason of this is that certain years have been specially favourable to the development of the plaice, so that a great many young plaice have been produced in these years whereas in other years the quantities are comparatively small. Accordingly, there is an interchange of "good" and "bad" or "rich" and "poor" brood years and fish from the rich brood years may predominate in the catches through several years. In the said paper by Å. J. C. Jensen (**1933**) conditions in the Horns Reef Area are stated in the following way: 1921 was an average year, 1922 a rich brood year, 1923 average, 1924 poor, 1925 rich, 1926 below average, 1927 average, 1928 rich, and 1929 a poor brood year. So we have had 3 rich year-classes, viz. of 1922, 1925, and 1928, and in the following we shall see that these statements are in perfect accord with the age-analyses of Table 6.

Starting with 1928 we see that the 3-years-old fish — of the rich 1925 year-class — predominate in number both at the Thyborøn and at the Horns Reef; but besides there is still among the fish of the Horns Reef a large quantity of 6-years-old plaice belonging to the rich year-class of 1922. In 1929 only one year-class predominates, but then it is a very numerous one: no less than 82.4 % of the fish belongs to the 1925 year-class, the individuals of which are now 4 years old. In 1930 this rich year-class still exceeds all others though now it constitutes only 51.9 % of the total; evidently a great many plaice of this year-class have disappeared since last year, a fact which must no doubt principally be put down to the fishery. In 1931 the 3- and 4-years-old plaice are in the majority. The 1925 year-class has nearly disappeared: it has either been fished out or it has emigrated from the area. The bulk of the plaice belongs to the average year-class of 1927, but already now there is a fairly numerous representation of the 3-years-old fish of the rich 1928 year-class, which makes up more than 30 % of the total number. In 1932 the IV-Group dating from 1928 is preponderant, no less than three fourths of the stock belonging to this year-class. 1933 shows much the same state of things: no less than 76 % of more than 1 000 fish examined still belong to the 1928 year-class, which has obviously been a very rich one. It may be added that as late as April 1934 the plaice of the 1928 year-class — which were by now 6 years old — made up nearly half the stock of the Horns Reef area. Obviously all later year-classes have been rather poor ones; however, recent investigations have shown that 1932 has been a rich brood year, so that this year-class will be likely to prevail in the transplantations of the next few years — to begin with as the III-Group of the year 1935.

On the whole it appears from Table 6 that even the rich year-classes do not come to prevail in the catches until they are 3 years old, i. e. as III-Group, because, until then, they do not attain the size which is required for transplantation. It is also seen by the table that only the richest of all year-classes are of any importance in the catches as VI-Group, that is to say as 6-years-old fish: although the 1925 year-class was a rich one, it practically disappears from the catches after 1930, in other words before the fish of this year-class are fully 6 years old. However, both of the two rich year-classes 1922 and 1928 play a considerable part as late as 6 years after their appearance: they constitute respectively 21 and 50 % of the stock of plaice at the Horns Reef. It was already mentioned that the disappearing of the older year-classes from the catches in the Horns Reef area is caused partly by the fishery, partly by emigration — when the fish are 5—6 years old and approach the stage of maturity they emigrate into deeper water in order to breed — but as both these factors must be supposed to have affected the stock fairly uniformly throughout the series of years considered, the conditions mentioned above can only mean that 1928 was the richest of the three rich year-classes with 1922 and 1925 as numbers 2 and 3.

In following the oblique lines of Tabel 6, which combine the year-classes separately, we get a good idea of the numerical strength and the average size of the individual year-classes in the different years. It should be noticed that the figures of the year 1930 are hardly so reliable as the rest; firstly, the number of fish examined was far smaller, secondly, there is reason to believe that the sorting of the catches was specially careful because in this year only a comparatively small quantity of fish was transplanted, so that but few individuals outside the measures stipulated (17—25 cm.) were included; the latter fact is no doubt the reason of the total absence of the 2-years-old fish and of the average lengths of the other age-groups being unusually high.

Finally, it will be noted that on the whole the

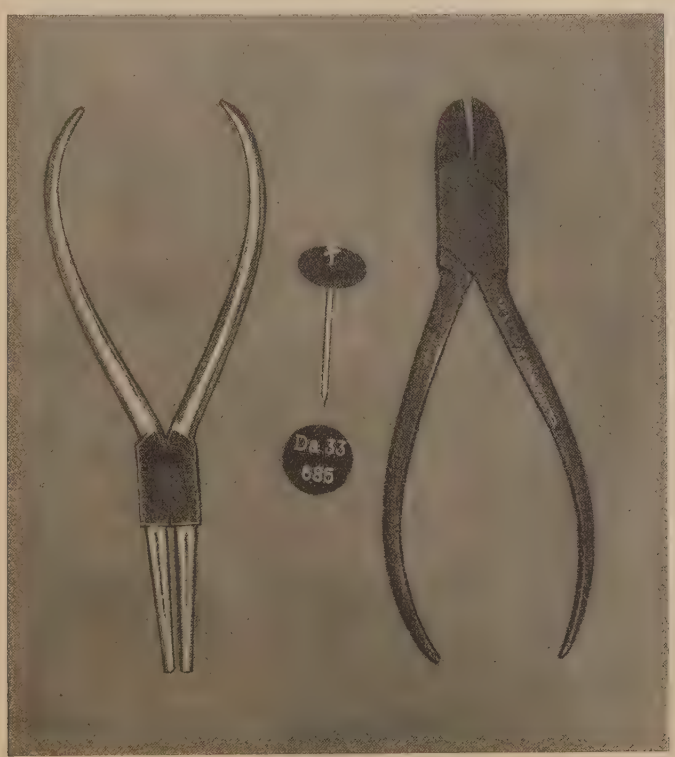
slowest rate of growth is found in the rich year-classes. If we follow the average lengths of the 1925 year-class through the years, we see that the growth from the III- to the IV-Group only amounts to 1.4 cm. and thus is far below the average growth (which is 2.5 cm.). We find fairly the same state of things in the 1928 year-class, the growth of which was but 1.2 cm.; all other year-classes show a higher rate of growth. The reason why the growth of the rich year-classes is slower than that of the poor ones is no doubt the well-known fact that the Horns Reef area — like the Nissum Broad inside the Thyborøn — is permanently overpopulated with plaice; consequently there is beforehand a hard competition for food, and when furthermore a particularly numerous year-class adds to the density of the population, the competition for food will naturally become still harder and cause a decrease of the rate of growth.

II. The Markings.

A. Methodics.

During the annual transplantations a great work has been done in marking considerable numbers of plaice. The purpose of this work has been to enable us to estimate the progress and the effects of the transplantations; not only do the recaptures of marked plaice inform us of the proportional number of plaice recaught: they also form the proofs of the growth and migrations of these fish.

Throughout the years the labels for the markings have been of the same kind: two ebonite buttons, one of which carries the nationality mark, year and the serial number; the buttons are fixed by means of a silver wire, which is inserted between two interneural spines (see Figs. 3 and 4). The labels are now made in this country at a price of 23 Øre (about 3 d.) apiece, including the silver wire. It is specially observed (1) that the edges of the ebonite buttons are rounded, so that they will not hurt the fish, (2)



H. Blegvad phot.

Figure 3. Label for plaice marking and implements by which to cut off and bend the silver wire. $^2/_3$ natural size.

that the figures and letters on the eye-side button are imprinted so deeply, that they cannot be extinguished, not even after a long stay in salt water, and (3) that the silver wire is of a convenient stiffness. Experience has shown that these labels, which are fixed in such a way that there is ample room left for the growth, do not inconvenience the plaice, even if they are carried for years; further, that the identification figures of the buttons are distinctly to be seen after several years; and that fish were also liberated in the transplantation areas. As the local stock of the years 1928—33 was very thin within the transplantation areas, these markings were generally carried out onboard a well-smack that had been hired to catch the Belt Sea fish in places with a comparatively numerous stock; these fish were kept in the well of the boat and were marked and liberated at the successive places of liberation. In April 1931 it was very difficult to procure a sufficiency of local plaice for these markings

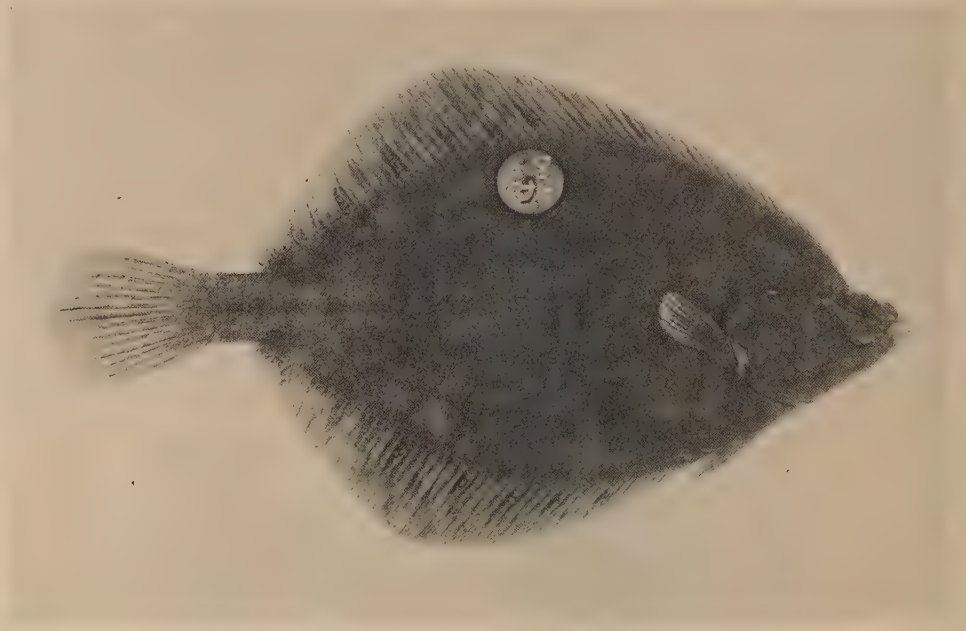


Figure 4. A marked plaice. $^3/_5$ natural size. H. Blegvad phot.

the labels are rarely torn out of the fish. The only disadvantage of the labels is that small marked fish are more liable to be caught in stationary gears than the same size of fish that are not marked, because the buttons are entangled in the meshes of the net in spite of the fish itself being able to pass. This fact should be considered in the following.

As to the fish destined for transplantation the markings were always carried out onboard the well-smacks simultaneously with the unloading of the fish at the various places of liberation; in all cases the fish marked thus constitutes part of the quantity liberated in the locality in question.

For the purpose of comparison a number of local plaice or Belt Sea fish, that is to say plaice caught in the Belt Sea waters, were marked together with the fish to be transplanted; these marked Belt Sea (H. Blegvad, **1932**, p. 89), and so Belt Sea fish were also bought from the fishermen of various localities. Consequently, part of the plaice were rather roughly handled, a fact which caused a comparatively low percentage of recapture.

During the transplantations the following marking experiments were carried out in the course of the years:

	Fish transplanted		Local fish	
Year	Number of individuals marked	Number of places of liberation	Number of individuals marked	Number of places of liberation
1928	3000	28	430	6
1929	2800	27	2800	27
1930	200	2	100	1
1931	2300	23	850	17
1932	2000	20	1000	20
1933	1850	19	1000	20
Total...	12150	119	6180	91

Both the transplanted and the local fish used for the markings had a length of 20—25 cm. the average length being 22.4 cm. Only in 1928 the local fish were larger, their average length being above 26 cm., and so they have been left out in the following.

B. The Recaptures.

Constant markings of fish were carried out only in the areas I—VIII, and so the following Table 7 only deals with the markings of these areas; the markings of 1930, including but few individuals, have also been left out.

The table gives a survey from the different

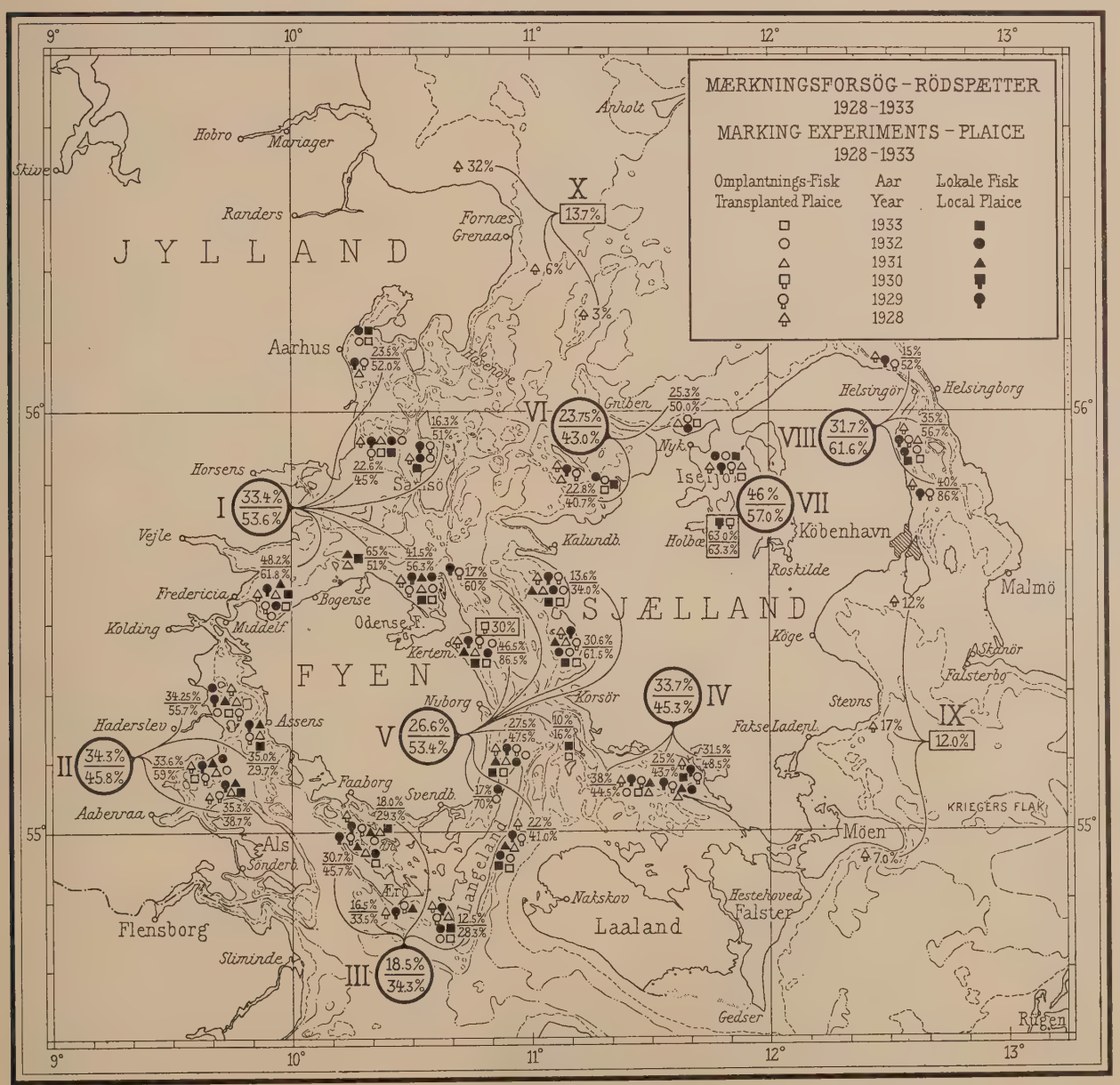


Figure 5. Positions of liberation of marked plaice in the different years and percentage recaptures of the individual localities and of the large areas of transplantation; above line percentage recapture of transplanted fish, below line of local fish.

Table 7. Percentages of recapture down to May 1st, 1934, from the markings carried out in the areas I—VIII (1930 not included.)

The figures of transplanted fish (Transpl.) are given in italics, those of the local Fish (Local) in common type. The figures in brackets denote the numbers of marked plaice.

Year	1928	1929		1931		1932		1933		1928-33	
	Transpl.	Local	Transpl.	Local	Transpl.	Local	Transpl.	Local	Transpl.	Local	Transpl.
Aarhus Bay	..	62 (100)	*28* (100)	..	*27* (100)	44 (50)	*16* (100)	50 (50)	*23* (100)	52 (200)	*23.5* (400)
S. of Tunø	*15* (100)	59 (100)	*24* (100)	—	*33* (100)	42 (50)	*19* (100)	34 (50)	*22* (100)	45 (200)	*22.6* (500)
W. of Samsø	*16* (100)	57 (100)	*17* (100)	..	..	56 (50)	*16* (100)	40 (50)	..	51 (200)	*16.3* (300)
Odense Gab	*29* (100)	75 (100)	*45* (100)	24 (50)	*56* (100)	78 (50)	*48* (100)	48 (50)	*29* (100)	56.3 (250)	*41.5* (500)
Æbelø	..	..	..	40 (50)	*65* (100)	..	..	62 (50)	..	51 (100)	*65.0* (100)
Baaring Vig	*37* (100)	79 (100)	*49* (100)	30 (50)	*69* (100)	68 (50)	*46* (100)	70 (50)	*40* (100)	61.8 (250)	*48.2* (500)
Whole Area I	*24.25* (400)	66.4 (500)	*32.6* (500)	31.3 (150)	*50* (500)	57.6 (250)	*29* (500)	50.7 (300)	*28.5* (400)	53.6 (1200)	*33.4* (2300)
Linderum	*10* (100)	79 (100)	*35* (100)	18 (50)	*52* (100)	70 (50)	*49* (100)	14 (50)	*25* (100)	55.7 (200)	*34.25* (500)
E. of Aarø	..	59 (100)	*25* (100)	16 (50)	*45* (100)	..	..	..	..	29.7 (200)	*35.0* (200)
Halk Hoved	*9* (100)	85 (100)	*40* (100)	24 (50)	*53* (100)	68 (50)	*47* (100)	22 (50)	*19* (100)	59.0 (200)	*33.6* (500)
N. of Als	*28* (100)	74 (100)	*36* (100)	20 (50)	*42* (100)	..	..	..	..	38.7 (200)	*35.3* (300)
Whole Area II	*15.7* (300)	74.3 (400)	*34* (400)	19.5 (200)	*48* (400)	69 (100)	*48* (200)	18 (100)	*22* (200)	45.8 (800)	*34.3* (1500)
Avernakø	*6* (100)	60 (100)	*27* (100)	18 (50)	*22* (100)	..	*17* (100)	10 (50)	..	29.3 (200)	*18* (400)
Off Søby	..	63 (100)	*31* (100)	36 (50)	*32* (100)	38 (50)	..	..	*29* (100)	45.7 (200)	*30.7* (300)
Vejsnæs Nakke	*19* (100)	39 (100)	*14* (100)	28 (50)	..	..	..	..	..	33.5 (150)	*16.5* (200)
Ristinge Bay	*9* (100)	35 (100)	*8* (100)	..	*15* (100)	34 (50)	*13* (100)	16 (50)	*17* (100)	28.3 (200)	*12.5* (500)
Whole Area III	*11.3* (300)	49.3 (400)	*20* (400)	27.3 (150)	*23* (300)	36 (100)	*15* (200)	13 (100)	*23* (200)	34.3 (750)	*18.5* (1400)
Kirkegrunden	..	55 (100)	*18* (100)	30 (50)	*32* (100)	46 (50)	..	..	..	43.7 (200)	*25* (200)
Vene Grund	*13* (100)	67 (100)	*27* (100)	22 (50)	*49* (100)	..	*50* (100)	..	*51* (100)	44.5 (150)	*38* (500)
Karrebæksminde	*27* (100)	63 (100)	*36* (100)	..	..	..	..	34 (50)	..	48.5 (150)	*31.5* (200)
Whole Area IV	*20* (200)	61.6 (300)	*27* (300)	26 (100)	*40.5* (200)	46 (50)	*50* (100)	34 (50)	*51* (100)	45.3 (500)	*33.7* (900)
E. of Langeland	*16* (100)	56 (100)	*26* (100)	18 (50)	*22* (100)	52 (50)	*37* (100)	38 (50)	*9* (100)	41 (250)	*22* (500)
Stokkebæk Flak	*16* (100)	56 (100)	*31* (100)	42 (50)	*44* (100)	58 (50)	*30* (100)	34 (50)	*16* (100)	47.5 (250)	*27.5* (500)
Dagelykke	..	..	..	..	..	70 (50)	*17* (100)	..	..	70 (50)	*17* (100)
Agersø-Omø	..	..	..	..	..	..	..	16 (50)	*10* (100)	16 (50)	*10* (100)
Kerteminde Bay	*49* (100)	96 (100)	*67* (100)	72 (50)	*53* (100)	94 (50)	*41* (100)	84 (50)	*22* (100)	86.5 (250)	*46.5* (500)
Fyens Hoved	..	60 (100)	*17* (100)	..	..	..	..	..	..	60 (100)	*17* (100)
Musholm	*20* (100)	66 (100)	*26* (100)	16 (50)	*39* (100)	90 (50)	*38* (100)	74 (50)	*30* (100)	61.5 (250)	*30.6* (500)
Reersø	*14* (100)	46 (100)	*9* (100)	4 (50)	*24* (100)	66 (50)	*11* (100)	20 (50)	*10* (100)	34 (250)	*13.6* (500)
Whole Area V	*23* (500)	63.3 (600)	*29.3* (600)	30.4 (250)	*36.4* (500)	71.7 (300)	*29* (600)	44.3 (300)	*16.2* (600)	53.4 (1450)	*26.6* (2800)
Sejerø, Nexelø	*13* (100)	34 (100)	*7* (100)	..	*33* (100)	40 (50)	*33* (100)	48 (50)	*28* (50)	40.7 (200)	*22.8* (450)
Nyrup Bay	..	..	..	..	*33* (100)	50 (50)	*25* (100)	..	*18* (100)	50 (50)	*25.3* (300)
Whole Area VI	*13* (100)	34 (100)	*7* (100)	..	*33* (200)	45 (100)	*29* (200)	48 (50)	*23* (150)	43 (250)	*23.75* (750)
Area VII Isefjord	*31* (100)	69 (200)	*63* (200)	..	*50* (100)	48 (50)	*48* (100)	54 (50)	*38* (100)	57 (300)	*46* (600)
Hornbæk	*19* (200)	52 (100)	*11* (100)	..	..	..			..	52 (100)	*15* (300)
Nivaa	*36* (100)	84 (100)	*60* (100)	..	*19* (100)	42 (50)	*41* (100)	44 (50)	*19* (100)	56.7 (200)	*35* (500)
Taarbæk	*30* (100)	86 (100)	*50* (100)	..	..	..	..	..	..	86 (100)	*40* (200)
Whole Area VIII	*28.3* (400)	74 (300)	*40.3* (300)	..	*19* (100)	42 (50)	*41* (100)	44 (50)	*19* (100)	61.6 (400)	*31.7* (1000)
Total I—VIII	*21.00* (2300)	63.56 (2800)	*30.63* (2800)	26.94 (850)	*39.52* (2300)	57.70 (1000)	*32.10* (2000)	40.65 (1000)	*23.95* (1850)	49.30 (5650)	*29.68* (11 250)

Table 8. Number of positions of liberation and of marked plaice liberated in the areas I—VIII.

Area	1928	1929		1931		1932		1933		Total	
	Transpl.	Loc.	Transpl.	Loc.	Transpl.	Loc.	Transpl.	Loc.	Transpl.	Loc.	Transpl.
I.....	4 (400)	5 (500)	5 (500)	3 (150)	5 (500)	5 (250)	5 (500)	6 (300)	4 (400)	19 (1200)	23 (2300)
II.....	3 (300)	4 (400)	4 (400)	4 (200)	4 (400)	2 (100)	2 (200)	2 (100)	2 (200)	12 (800)	15 (1500)
III.....	3 (300)	4 (400)	4 (400)	3 (150)	3 (300)	2 (100)	2 (200)	2 (100)	2 (200)	11 (750)	14 (1400)
IV	2 (200)	3 (300)	3 (300)	2 (100)	2 (200)	1 (50)	1 (100)	1 (50)	1 (100)	7 (500)	9 (900)
V	5 (500)	6 (600)	6 (600)	5 (250)	5 (500)	6 (300)	6 (600)	6 (300)	6 (600)	23 (1450)	28 (2800)
VI	1 (100)	1 (100)	1 (100)	..	2 (200)	2 (100)	2 (200)	1 (50)	2 (150)	4 (250)	8 (750)
VII	1 (100)	1 (200)	1 (200)	..	1 (100)	1 (50)	1 (100)	1 (50)	1 (100)	3 (300)	5 (600)
VIII	3 (400)	3 (300)	3 (300)	..	1 (100)	1 (50)	1 (100)	1 (50)	1 (100)	5 (400)	9 (1000)
	22 (2300)	27 (2800)	27 (2800)	17 (850)	23 (2300)	20 (1000)	20 (2000)	20 (1000)	19 (1850)	84 (5650)	111 (11250)

places of liberation of the percentages of marked plaice, which have been recaught by the fishermen down to May 1st, 1934, and sent to the Biological Station, the Fisheries Inspectorate, or the chosen representatives of the Station at the large fishing harbours. The numbers of plaice marked are given in the brackets of the table and will further emerge from Table 8, which also gives the number of positions of liberations within each of the transplantation areas I—VIII. As will be seen a total of 5 650 local and 11 250 transplanted plaice were marked inside the areas I—VIII during the 5 years 1928—29 and 1931—33. The chart Figure 5 gives a survey of the places of liberation in the different years and of the average percentages of recapture both inside the larger transplantation areas and at the individual places of liberation[1]).

In judging the separate percentages of recapture in Table 7 it should be kept in mind that these percentages are conditioned on two principal factors: the vitality of the marked plaice and the fishing intensity in the localities to which the marked plaice have spread. As to the latter point we shall see later that most of the plaice marked were recaught very close to the localities of liberation, so that we need but consider the fishing intensity in the very area of liberation.

a. The vitality of the marked fish.

As to the vitality of the plaice marked it should be mentioned at once that it is hardly lowered by the act of marking. Experience shows that the small wound made with the silver needle practically never hurts the fish; they may go with the labels for years and grow up to be large and fat without showing signs of the labels having handicapped them at all. However, it is evident that the vitality of the transplanted plaice must be lowered by the handling to which they are exposed: fishing, stay in well-boxes, transport over land, another stay in well-boxes, and finally transport by well-smacks. Add to this that the plaice to be transplanted are liberated in places where conditions of living are quite different from those of the localities, in which they were caught; the salinity of the water is much lower, and food animals and conditions of bottom in the Belt Sea waters and in the Horns Reef Area have but few points of resemblance. This finds expression in the fact that on the whole far smaller percentages are recaptured of the transplanted fish than of the local, marked Belt Sea fish. The only exception is the year 1931 when the local, marked fish, as mentioned above, on account of special conditions were exposed to the same rough handling as the transplanted fish (see Table 7). Table 7 says, that in the areas I—VIII the average figures of the series of years considered show that 29.68 % of the transplanted plaice, but no less than 49.30 % of the local plaice marked were recaught. In taking only the average figures representing the recapture of marked plaice year by year we get the following survey:

Percentages of recapture.

	Local fish	Fish transplanted
1928	..	21.0
1929	63.56	30.63
1931	26.94	39.52
1932	57.70	32.1
1933	40.65	23.95
Average...	49.30	29.68

[1]) The area IX of the chart (the Baltic) in 1928 yielded remarkably small percentages of recapture; most probably the fresh water and the long transport have caused a high mortality among the fish transplanted, and so transplantations to this area have been abandoned during later years.

Table 9.

Area	Locality	1932 Sailing time in hours	1932 Wind	1932 Sea	1932 Recapture per cent.	1933 Sailing time in hours	1933 Wind	1933 Sea	1933 Recapture per cent.
I	Baaring Vig	1	0	0	46	1	SSW. 1	0	40
II	Linderum	3	strong NW.	slight	49	3	fresh WNW.	slight	25
I	Odense Gab	3½	SE. 2	calm	48	4	fresh SW.	3	29
	S. of Tunø	5	S. 3	slight	19	6	SW. 3—4	2—3	22
	W. of Samsø	5	SSW 3.	slight	16	..	..	..	..
II	Halk	6	SW. 4—7	rough	47	5½	0	0	19
III	Avernakø	6	E. 4	slight	17	..	..	..	..
	Søby	..	..	..	..	7	0	0	29
I	Aarhus Bay	8	0	0	16	7	NW. 4	2	23
V	Kerteminde Bay	8	slight S.	calm	41	8½	fresh NE.	moderate	22
	Musholm	8	fresh S.	moderate	38	9	ENE. 3	slight	30
III	Ristinge Bay	9	E. 4	slight	13	9	0	0	17
V	Reersø	9	fresh S.	moderate	11	10	ENE. 3	slight	10
	Stokkebæk Flak	10	fresh SE.	slight	30	10	NW. 3	slight	16
	Dagelykke	11	fresh SW.	slight	17	..	..	..	..
VI	Nexelø	11½	S. 1	0	33	8	WNW. 5	5	28
V	Omø	..	..	..	..	12	NW. 3	slight	10
VI	Nyrup Bay	12½	E. 1	some swell	25	12½	N. by W. 3	slight	18
V	E. of Langeland	15	slight S.	slight	37	13	NW. 3	slight	9
IV	Kirke- and Venegrund	15	slight SW.	slight	50	14	NW.-SW. 3	2	51
VII	Isefjord	16½	N. 1—2	Some swell	48	13½	NNW. 3	slight	38
VIII	Nivaa	17	ESE. 2	slight	41	19½	0	0	19

So we see that as regards the fish transplanted the year 1928 shows the lowest percentage of recapture of the whole series of years, viz. 21 %; but this state of things is a natural consequence of the fact that 1928 was the first year in which large-scale transplantations were carried out, so that we had not yet gathered the experience of later years respecting the keeping and the transport of the fish. Coincidently with improvements on the procedure we find a rise in the percentage recaptures of the transplanted fish as a whole: in 1929 it rose to 30.6, in 1931 even to 39.5. In 1932 and 1933[1]) the percentage went down, which is no doubt due to the diminishing fishing intensity of these years, in which the stock of plaice had been thinned to the utmost, and many fishermen had taken to other fisheries. The fact is that all the years between 1927 and 1932 were bad brood-years of the plaice in our inner waters; so, when the rich 1927 year-class had been fished out during the year 1931, the yield of the plaice fishery in the Belt Sea dropped considerably during the following two years: from 922 tons in 1931 to 846 tons in 1932 and to 702 tons in 1933. We cannot expect another rise of the yield until 1934 when the plaice of the rich 1932 year-class have gradually grown up to become marketable fish.

It is a well-known fact that a long transport in well-smacks, especially by unfavourable weather, may lower the vitality of the fish considerably. As far as possible due regard has been given to this fact during the transplantations because it was in the interests of the suppliers that the fish furnished for the transplantations should be delivered in the best of conditions, so that they need not run the risk of having the load or part of it rejected by the controllers. It may be said at once that in the very few cases of a rejection only a small part of the loads of a few well-smacks had to be discarded. For the purpose of investigating whether long transports and unfavourable conditions of weather might influence the fish, which otherwise seemed to be likely to live, in a way as to lower their vitality, an arrangement was made in 1932 on the initiative of the Biological Station that the duration of the transport, the force of the wind, and the character of the sea should be put down on the receipts for the fish supplied for the transplantations. A comparison between information of this kind and the

[1]) The results of the experiments being calculated per May 1st, 1934, the percentage of recapture for the year 1933 will possibly by later accounts turn out to be somewhat higher.

percentages of recapture in the different localities has shown that in all cases when the fish to be transplanted were estimated to be likely to live, the percentages of recapture have proved these estimates to be correct. Consequently the supposition advanced in my preliminary report on the transplantations of the years 1928—31 (H. Blegvad, **1932**, p. 89—90) of a direct connexion between a long transport in well-smacks and the vitality of the plaice cannot be maintained for the transplantations as a whole. In any case when, on the arrival at the position of liberation, the plaice seemed to be absolutely likely to live, they have in fact turned out to be so, no matter how long the duration the transport.

If we arrange the localities of liberation serially according to the time required by the well-smacks to reach these places from Fredericia, and if we compare sailing time, wind, and sea during the transport with the percentages of recapture in the individual localities (down to May 1st, 1934), we get the figures put down in Table 9, p. 26.

It is seen that there is no connexion whatever between a long transport and a low percentage of recapture; on the contrary the highest percentages are met with in Smaalandsfarvandet (Area IV), to which place the transport lasts 14—15 hours; nor do strong winds and high sea cause any low percentage of recapture. In 1932 at Halk the force of wind was 4—7 and the sea rough, but still the percentage of recapture was 47 as against 19 in 1933 when the weather was calm during the transport. In the Aarhus Bay we find in 1932 a recapture percentage of 16, but in 1933 one of 23 although in the latter year the force of the wind was 4 and the sea 2 during the transport, which lasted 30 minutes longer than the year before.

b. The fishing intensity.

We may then take it for granted that the vitality of all marked plaice transplanted has been fairly the same on their liberation throughout the series of years considered here, with the exception of 1928. The figures in Table 7 (and the chart Figure 5), show, therefore, that in Area I the fishing intensity is rather high in the water north of Funen, but a little below mean at Samsø and in the Aarhus Bay. In Area II (the Little Belt) the fishing intensity was high, too, but fell considerably in 1933. Inside Area III Vejsnæs Nakke and Ristinge Bay have a very low fishing intensity; here the plaice fishing is carried on rather far from the coast. Area IV exhibits heavy recaptures, even during recent years; an intense otter seine fishery is pursued here. The conditions of Area V are rather heterogeneous: the Kerteminde Bay, Stokkebæk Flak and Musholm Bay are overcrowded with plaice-boats, but in the remaining localities of the area the plaice fishing is but insignificant. As to Area VI the recaptures were unexpectedly small in 1928 and 1929; otherwise they were a little above mean. In the Isefjord (Area VII) there was a high fishing intensity throughout the years, and the same may be said of the Sound (Area VIII) with the exception of the localities Hornbæk and Nivaa in 1931 and 1933.

c. The recaptures of the different months.

The transplantations and markings were carried out every year in the month of April, and so it is possible to tabularize the recaptures of each separate month after the liberation for all years collectively. This was done in Table 10, which gives the percentage recaptures of the different months, including both the transplanted and the local plaice. April, the month of liberation, was marked down as 0, the following months getting continuous numbers from 1—34, and so it is possible to read directly by the figures how many per cent. of the marked plaice liberated have been recaught inside each area of transplantation after any number of months. A summary of Table 10 is given in Table 11.

It appears distinctly from these tables that a comparatively great number of fish are recaught a very short time after their liberation: 11.4 % of the transplanted and 21.4 % of the local, marked plaice are the average recaptures of all areas before June 1st. Of course this early fishing is a disadvantage because the fish do not attain a profitable size and value until late in autumn. But it should be remembered that in most cases the plaice are taken alive; in the months of April and May the plaice transplanted are still undersized fish, and according to the Danish Fisheries' Act such fish must be liberated at once. Consequently only the marked plaice are landed while most of the plaice transplanted are liberated once more if they are caught within a short time after the transplantation. The principal reason why so many marked fish are caught a short time after their liberation is that the plaice migrate towards the coasts in spring (see chapter C, e, p. 61). During this migration towards the shallow water

Table 10. Percentage of recapture per month of transplanted (italic figures)

Number of months after liberation ...	1. year																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Area	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.	J.	F.	Mar.	A.	M.	Jn.	Jl.	A.
I	*3.21*	*8.38*	*3.60*	*3.34*	*3.60*	*2.00*	*1.13*	*0.96*	*0.83*	*2.13*	*1.00*	*0.78*	*0.48*	*0.48*	*0.22*	*0.43*	*0.13*
	6.32	14.90	7.74	3.95	3.53	2.79	1.58	1.00	1.63	2.95	1.53	1.16	0.95	0.84	0.74	0.74	0.42
II	*1.87*	*7.53*	*4.66*	*4.93*	*2.40*	*2.46*	*1.86*	*0.67*	*1.27*	*2.66*	*1.00*	*0.80*	*0.53*	*0.53*	*0.13*	*0.13*	*0.13*
	2.25	10.34	9.51	9.18	4.76	3.25	1.17	0.67	0.84	0.75	1.08	0.42	0.33	0.42	0.50	0.08	0.08
III	*1.57*	*4.29*	*3.00*	*2.36*	*1.36*	*0.86*	*0.21*	*0.14*	*0.71*	*1.64*	*0.86*	*0.50*	*0.21*	*0.29*	*0.21*	..	*0.14*
	2.46	6.00	6.46	3.91	3.00	1.19	1.27	1.27	1.64	2.09	1.82	0.91	0.27	0.36	0.64	0.27	0.09
IV	*0.89*	*4.34*	*4.67*	*7.01*	*6.34*	*1.78*	*1.11*	*1.22*	*1.22*	*1.78*	*0.78*	*0.56*	*0.33*	*0.33*	*0.67*	*0.11*	..
	1.57	10.15	9.00	8.43	6.57	1.71	1.57	1.43	0.43	0.86	1.00	0.57	0.29	0.43	0.86	0.29	0.14
V	*2.93*	*12.78*	*3.04*	*1.75*	*1.22*	*0.68*	*0.36*	*0.18*	*0.57*	*0.68*	*0.54*	*0.43*	*0.32*	*0.36*	*0.11*	*0.25*	*0.11*
	15.39	16.52	8.65	5.04	2.83	0.52	0.43	0.35	0.43	0.61	0.87	0.35	0.26	0.57	0.17	0.30	0.04
VI	*1.75*	*3.25*	*1.63*	*2.85*	*1.85*	*1.38*	*0.50*	*1.00*	*2.75*	*2.75*	*1.25*	*0.87*	*0.13*	..	*0.25*	*0.50*	*0.13*
	5.00	6.25	6.00	9.25	4.00	1.75	1.00	0.75	1.75	1.75	1.75	0.75	0.75	1.25	..	..	0.50
VII	*5.70*	*11.70*	*10.60*	*10.20*	*3.00*	*1.80*	*0.50*	*0.30*	*0.60*	..	*0.20*	..	*0.20*	..	*0.60*	..	..
	19.89	14.83	11.67	7.50	1.47	0.17	0.17	0.17	..	0.17	..	0.17	..	..	..	0.17	..
VIII	*0*	*17.91*	*7.01*	*2.22*	*1.22*	*0.22*	*0.56*	*0.67*	*0.22*	*0.56*	*0.44*	*0.22*	*0.22*	*0 11*	..	*0.11*	..
	12.60	24.40	7.40	8.60	2.20	1.20	0.80	1.20	0.40	0.60	0.20	0.60	0.40	0.40	..	0.60	..
I—VIII average ...	*2.31*	*9.09*	*4.07*	*3.52*	*2.46*	*1.37*	*0.79*	*0.59*	*0.92*	*1.57*	*0.78*	*0.57*	*0.34*	*0.36*	*0.19*	*0.23*	*0.10*

many of the small marked plaice are caught in nets, for on account of the button-shaped labels they are more liable to be caught in nets than the fish that have not been marked. The statistics below shows in which kind of gears the fish marked and transplanted were recaught in the months of April and May 1933.

Area	Month	Pound net	Plaice net	Otter seine	Total
I.	April	7	3	3	13
	May	11	8	11	30
II.	April	..	1	2	3
	May	1	4	2	7
III.	April	..	2	1	3
	May	..	4	..	4
IV.	April	1	..	4	5
	May	..	..	2	2
V.	April	..	20	..	20
	May	..	12	6	18
VI.	April	..	1	..	1
	May	..	5	..	5
VII.	April	2	1	..	3
	May	8	9	..	17
VIII.	April	..	..	..	..
	May	..	2	..	2
I-VIII.	April	10 (21 %)	28 (58 %)	10 (21 %)	48
	May	20 (23 %)	44 (52 %)	21 (25 %)	85
	April + May	30 (23 %)	72 (54 %)	31 (23 %)	133

In other words much more than half the marked fish recaught in April and May are caught in plaice nets and nearly one fourth of them are caught in pound nets on the coasts.

Tables 10 and 11 further show that the catches of marked fish are not equally heavy in all localities, In the areas II, III, IV, and VI (The Little Belt, the water round Ærø, Smaalandshavet, and N. W. of Seeland) the recaptures at the beginning of June are as low as 5.1—9.4 % as regards the transplanted, 8.5—12.5 % as regards the local plaice.

A study of the individual figures of Table 10 discloses the interesting fact that while the month of May nearly everywhere exhibits the heaviest recaptures, which are followed by a gradual decrease of the catches in summer, there is a distinct rise of the recaptures during the month of January, a fact which must be explained for in the following way: after their migration towards the coasts in early spring the plaice in summer spread in all directions towards the intermediate depths; during the cold season they will gather again in deeper water (see Chapter C, e, p. 61) where at this season an intense plaice fishing is carried on. Exactly the same fluctuation of the recaptures, but now less pronounced, is met with in the second year after the liberation (Table 10, lower part): a rise of the recaptures in May, a decline during the summer, and another high rise (especially as regards the fish transplanted) in December—January. As late as the third year after the liberation we find traces of the same phenomenon, the few fish recaught practically all originating from the months of April—May and December—January.

If we want to examine, on the basis of Table 10, which of the areas of liberation have yielded the best returns of the transplantations, we should

nd local plaice in the Areas I—VIII. 1928—29 and 1931—33.

year							3. year											
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	?	Total
S.	O.	N.	D.	J.	F.	Mar.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.	J.		
.04	*0.04*	*0.04*	*0.13*	*0.17*	*0.09*	*0.04*	..	..	..	..	*0.04*	..	..	..	..	..	*0.09*	*33.4*
.26	0.11	0.16	0.11	0.05	..	..	..	..	..	..	..	..	..	..	..	..	0.16	53.6
.	*0.07*	*0.20*	*0.07*	*0.13*	*0.07*	..	*0.07*	*0.07*	..	..	..	..	..	..	..	..	*0.07*	*34.3*
.	..	..	0.17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	45.8
.	..	..	*0.14*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*18.5*
.18	..	0.18	0.18	..	..	..	..	0.09	..	..	..	..	..	..	..	..	..	34.3
.	..	..	*0.11*	*0.33*	..	..	..	..	..	..	..	..	..	..	*0.11*	..	..	*33.7*
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	45.3
.04	*0.04*	..	..	*0.04*	..	..	..	..	..	..	..	..	..	..	*0.04*	..	*0.18*	*26.6*
.04	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	53.4
.	..	*0.13*	*0.13*	*0.13*	*0.13*	*0.13*	..	*0.13*	..	..	..	..	..	..	..	..	*0.13*	*23.7*
.	..	..	..	..	..	0.25	..	..	..	..	..	..	..	..	..	0.25	..	43.0
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*0.60*	*46.0*
.	..	..	0.67	..	..	..	..	..	..	..	..	..	..	..	..	..	..	57.0
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*31.7*
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	61.6
.01	*0.03*	*0.06*	*0.08*	*0.10*	*0.05*	*0.02*	*0.01*	*0.02*	..	..	*0.01*	..	..	..	*0.02*	..	*0.10*	*29.7*

remember that in this respect it is not satisfactory to consider only the total recapture percentage of plaice liberated in the area in question. If for instance a high total percentage of recapture arises by most of the plaice being taken quite a short time after the liberation, it is of course of less value than a smaller percentage of recapture in which most of the plaice have had time and opportunity to develop into large and valuable individuals.

Speaking generally most of the plaice liberated in April may be reckoned to attain a profitable size in August; at this time they have already increased in length by about 5—6 cm. (see Chapter D). In Table 11 the figures of Table 10 are made up in such

Table 11. Summary of Table 10.

	1.				2.	3.	?	Total	
	0—1 M.	2—3 M.	4—11 M.	0—11 M.	12—23 M.	24—33 M.		0—33 M.	4—33 M.
Area	Apr.-Mj.	Jn.-Jl.	Aug.-Mr.	Apr.-Mr.	Apr.-Mr.	Apr.-Ja.			
I	*11.6*	*6.9*	*12.4*	*30.9*	*2.3*	*0.1*	*0.1*	*33.4*	*14.9*
	21.2	11.7	16.1	49.0	4.4	..	0.2	53.6	20.7
II	*9.4*	*9.6*	*13.1*	*32.1*	*2.0*	*0.1*	*0.1*	*34.3*	*15.3*
	12.6	18.7	12.9	44.2	1.6	..	..	45.8	14.5
III	*5.9*	*5.3*	*6.3*	*17.5*	*1.0*	..	..	*18.5*	*7.3*
	8.4	10.4	13.2	32.0	2.2	0.1	..	34.3	15.5
IV	*5.2*	*11.7*	*14.8*	*31.7*	*1.9*	*0.1*	..	*33.7*	*16.8*
	11.7	17.4	14.2	43.3	2.0	..	..	45.3	16.2
V	*15.7*	*4.8*	*4.7*	*25.2*	*1.2*	*0.1*	*0.2*	*26.6*	*6.2*
	31.9	13.7	6.4	52.0	1.4	..	..	53.4	7.8
VI	*5.0*	*4.5*	*12.3*	*21.8*	*1.7*	*0.1*	*0.1*	*23.7*	*14.3*
	11.2	15.3	13.5	40.0	2.8	0.2	..	43.0	16.5
VII	*17.4*	*20.8*	*6.4*	*44.6*	*0.8*	..	*0.6*	*46.0*	*7.8*
	34.7	19.2	2.3	56.2	0.8	..	..	57.0	3.2
VIII	*17.9*	*9.2*	*4.1*	*31.2*	*0.5*	..	..	*31.7*	*4.6*
	37.0	16.0	7.2	60.2	1.4	..	..	61.6	8.6
I—VIII	*11.4*	*7.6*	*9.1*	*28.1*	*1.5*	*0.05*	*0.1*	*29.7*	*10.7*
	21.4	14.2	11.3	46.9	2.3	0.02	0.03	49.3	13.6
% calculated from all recaptures	*38.4*	*25.6*	*30.4*	*94.4*	*5.1*	*0.2*	*0.3*	*100*	*36.0*
	43.4	28.9	22.9	95.2	4.7	0.04	0.06	100	27.7

? is included in the column: 4—33 months.

a way that besides information of the percentages of recapture down to the month of June and in June + July we get a survey of how many per cent. have been recaptured in August and onwards, both during the first year (third column) and on the whole (last column[1])). A look at these figures will show that the numbers of plaice transplanted are in many cases higher than those of the local fish although the total percentage recaptures of the latter are, without exception, much higher than those of the former. This fact decidedly goes to show that the transplantations of North Sea fish have in fact yielded far better results than might be expected from a mere contemplation of the total percentages of recaptures as compared with the corresponding percentages of the local fish. The reason why the local plaice are much more exposed to be caught during the first months after the liberation — Table 11 shows that this is the case anywhere in all areas — is most probably that on account of their briskness the local fish are more liable to be caught in the gears than fish transplanted, which during the first time after their liberation are exhausted with the long transport.

If we use the basis given above for an examination of which areas, judging by the marking experiments, have yielded the best results of the transplantations of North Sea fish, it appears from Table 11 that Area IV (the "Smaalandsfarvand") exhibits no less than 14.8 % of recaptures during the first year from the month of August inclusive, 1.9 % during the second and 0.1 % during the third year, a total of 16.8 %. Next come the Areas II (the Little Belt), I (the water round Samsø) and VI (NW. of Seeland) with approximately the same recaptures of 14—15 %; the rest of the areas of liberation yield but low figures, from 4.6 % (the Sound) to 7.8 % (the water round Ærø and the Isefjord) — and much too heavy recaptures during the first months after the liberation.

In the lower part of Table 11 it has been calculated, for all areas in one, how great a part of all recaptures took place within the various periods. It will be seen that while 30 % of the fish transplanted were recaptured within the 4th—11th month and 36 % within the 4th—33rd month, the corresponding figures of the local fish are much smaller, being only 22.9 and 27.7 %, respectively. We note further that no less than abt. 95 % of all recaptures of marked plaice, both local and transplanted ones, takes place during the first year, and only 4.7—5.1 % during the second year after the liberation.

d. How many of the fish transplanted are caught by foreign fishermen?

Of the plaice marked during the experiments by far the greater part was recaught by Danish fishermen.

Of the fish transplanted a total of 56 marked plaice were caught by foreign fishermen in the course of years. 22 individuals were caught by Swedish, 32 by German fishermen, and 2 by English fishermen in the North Sea.

The fish recaught by foreign fishermen had mainly been liberated in the Areas III and VIII (the waters round Ærø and the Sound), which border on foreign territorial waters. Further some were recaught in the international territory of the Kattegat and — as mentioned above — one or two individuals in the North Sea.

In 1931 Swedish fishermen caught fully one third of the marked plaice transplanted to the Sound, but on the whole it appears from the figures that foreign fishermen benefit on a very small part of the fish transplanted — judging from the marking experiments less than 0.5 %.

C. The migrations.

It is an obvious fact that information on the migrations of the fish transplanted is most important for the purpose of judging the economic value of the transplantations; it is of special importance to examine to which extent the plaice transplanted have left the areas of transplantation, and whether their migrations were at all different from those of the local Belt Sea fish. For this purpose the experimental markings offer an excellent material, for, speaking generally, we may take it for granted that the migrations of the marked plaice give a diminutive but true picture of the migrations of both transplanted plaice and local Belt Sea fish.

[1]) Here the figures of column ? have been included because the few recaptures of uncertain dates have mostly taken place after the fourth month.

a. The migrations from the individual places of liberation.

Figures 6—28 represent the migrations of transplanted or local, marked plaice down to May 1st,

Figure 6. Migrations of marked plaice. Transplanted North Sea plaice. 1928. I.

The places of liberation are given as circles with a point within. An arrow means the place of recapture of a male, a black dot that of a female. The figure affixed denotes the number of months passed since the liberation: 0 means "recaptured in April of the same year", 1 means "recaptured in May of the same year", etc. The letters G, SW or E mean that the plaice in question was recaptured by German, Swedish or English fishermen, respectively; all other recaptures were made by Danish fishermen. Where many fish have been recaptured within some small area, the individual localities of capture are given as black points (or collectively as a black field) enclosed by a circle. In the case of these fish information of number recaught, sex and months (M) passed since the liberation is affixed. When the place of recapture falls outside the map, longitude and latitude are stated.

Figure 7. Migrations of marked plaice. Transplanted North Sea plaice. 1928. II.
As to legend see Figure 6.

M.	♂	♀
0	2	3
I	4	1
II	3	2
III	1	2
VI	0	1
Total	10	9

M.	♂	♀
0	0	1
I	5	10
II	1	1
Total	6	12

M.	♂	♀
I	2	0
II	2	4
IV	1	1
Total	5	5

M.	♂	♀
I	5	9
II	1	4
III	1	3
Total	7	16

M.	♂	♀
I	1	8

M.	♂	♀
I	8	10
II	1	1
III	6	2
IV	0	1
IX	1	0
Total	16	14

Figure 8. Migrations of marked plaice. Transplanted North Sea plaice. 1929. I.
As to legend see Figure 6.

Figure 9. Migrations of marked plaice. Transplanted North Sea plaice. 1929. II.
As to legend see Figure 6.

Figure 10. Migrations of marked plaice. Transplanted North Sea plaice. 1929. III.
As to legend see Figure 6.

Figure 11. Migrations of marked plaice. Transplanted North Sea plaice. 1931. I.
As to legend see Figure 6.

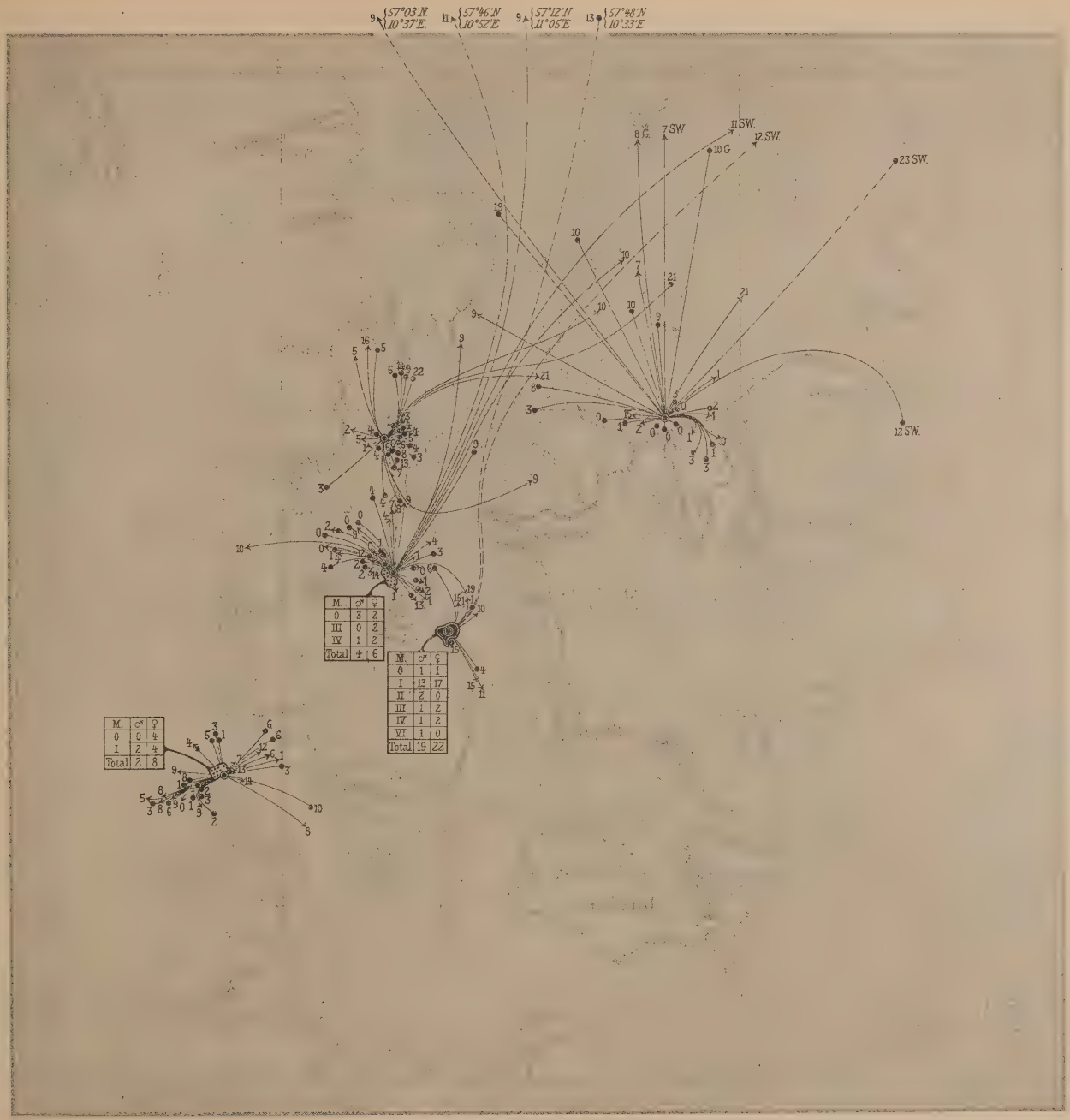


Figure 12. Migrations of marked plaice. Transplanted North Sea plaice. 1931. II.
As to legend see Figure 6.

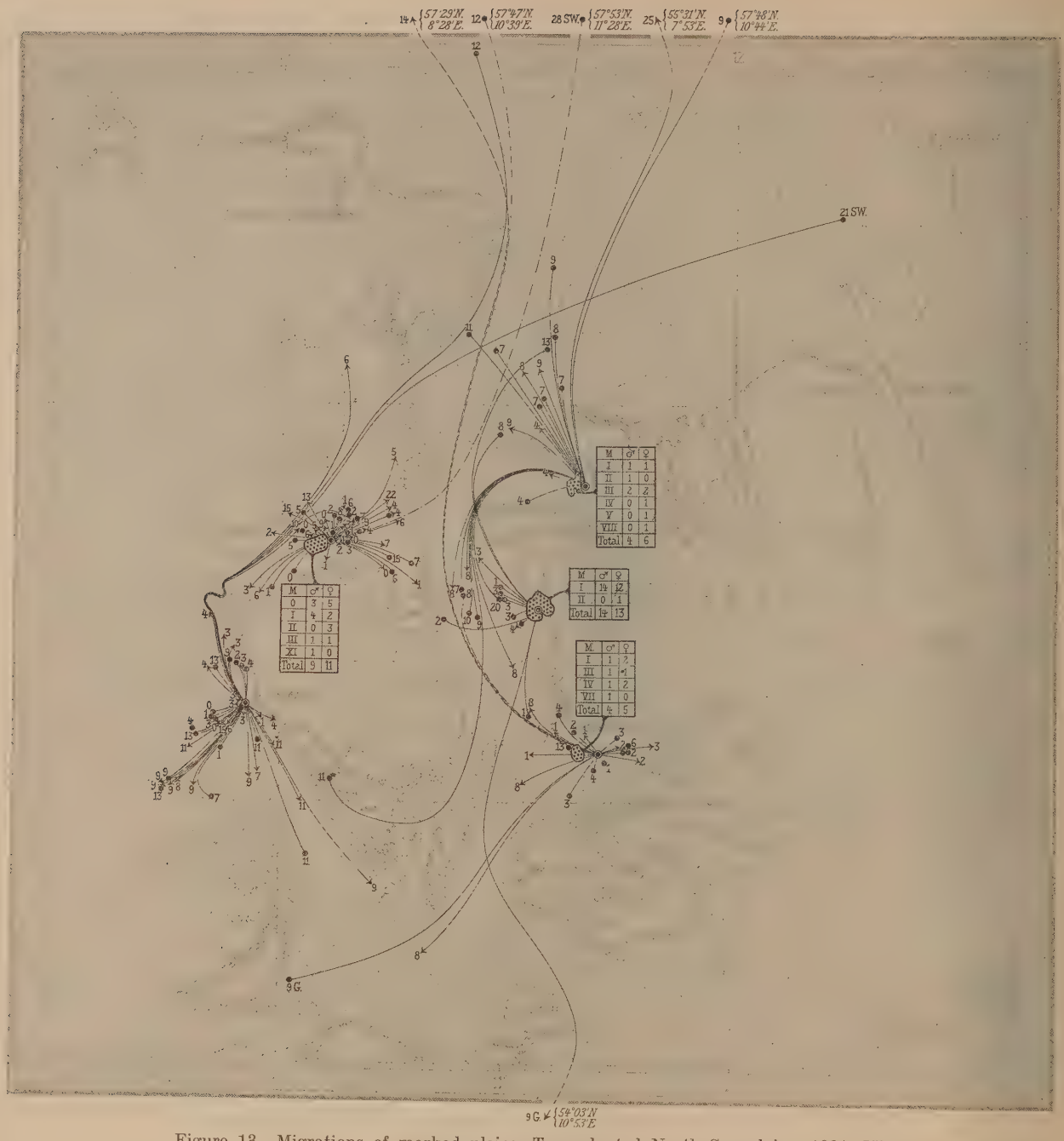


Figure 13. Migrations of marked plaice. Transplanted North Sea plaice. 1931. III.
As to legend see Figure 6.

Figure 14. Migrations of marked plaice. Transplanted North Sea plaice. 1931. IV.
As to legend see Figure 6.

Figure 15. Migrations of marked plaice. Transplanted North Sea plaice. 1932. I.
As to legend see Figure 6.

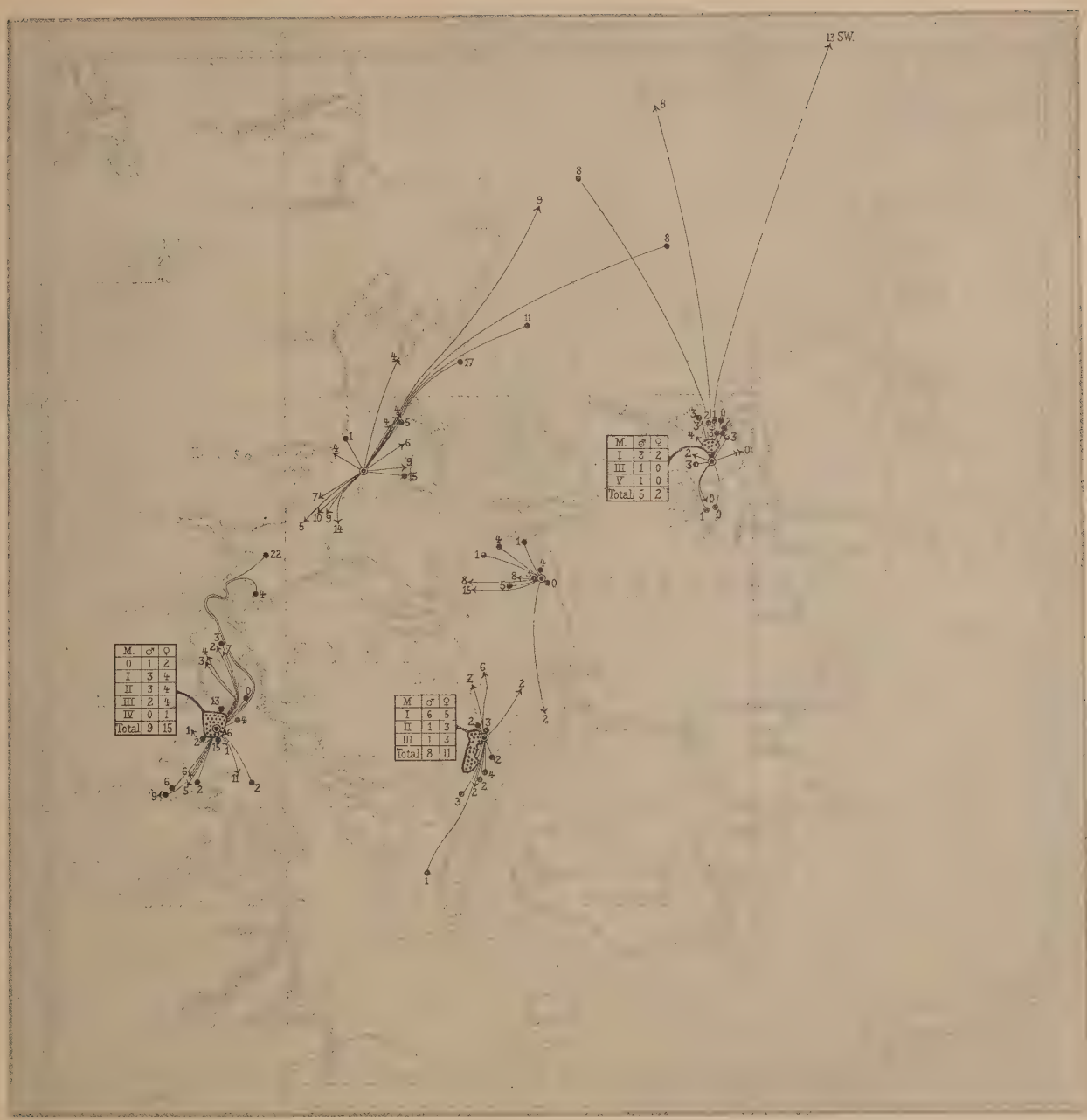
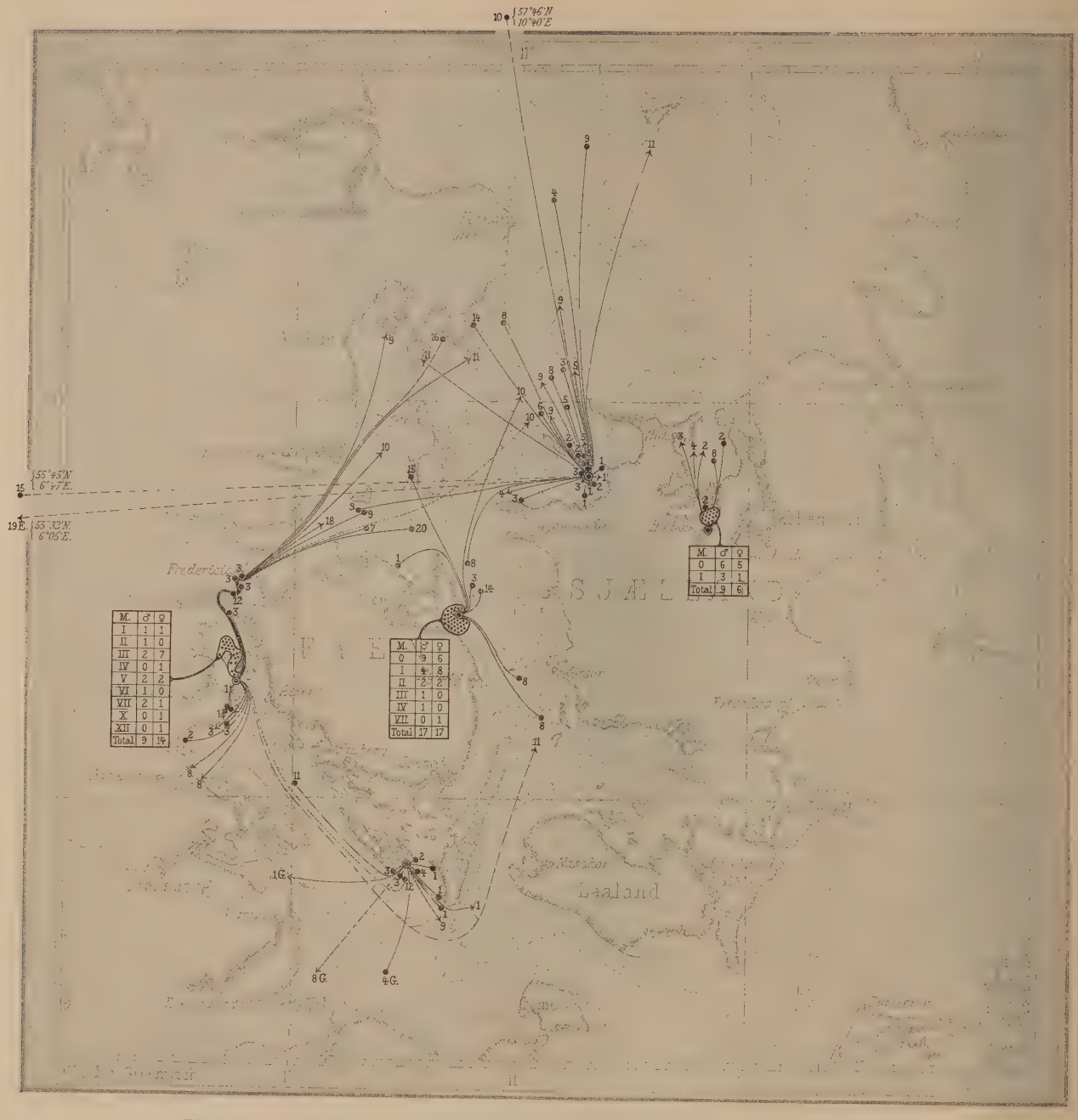


Figure 16. Migrations of marked plaice. Transplanted North Sea plaice. 1932. II.
As to legend see Figure 6.



M.	♂	♀
I	1	1
II	1	0
III	2	7
IV	0	1
V	2	2
VI	1	0
VII	2	1
X	0	1
XII	0	1
Total	9	14

M.	♂	♀
0	9	6
I	4	8
II	2	2
III	1	0
IV	1	0
VII	0	1
Total	17	17

M.	♂	♀
0	6	5
I	3	1
Total	9	6

Figure 17. Migrations of marked plaice. Transplanted North Sea plaice. 1932. III.
As to legend see Figure 6.

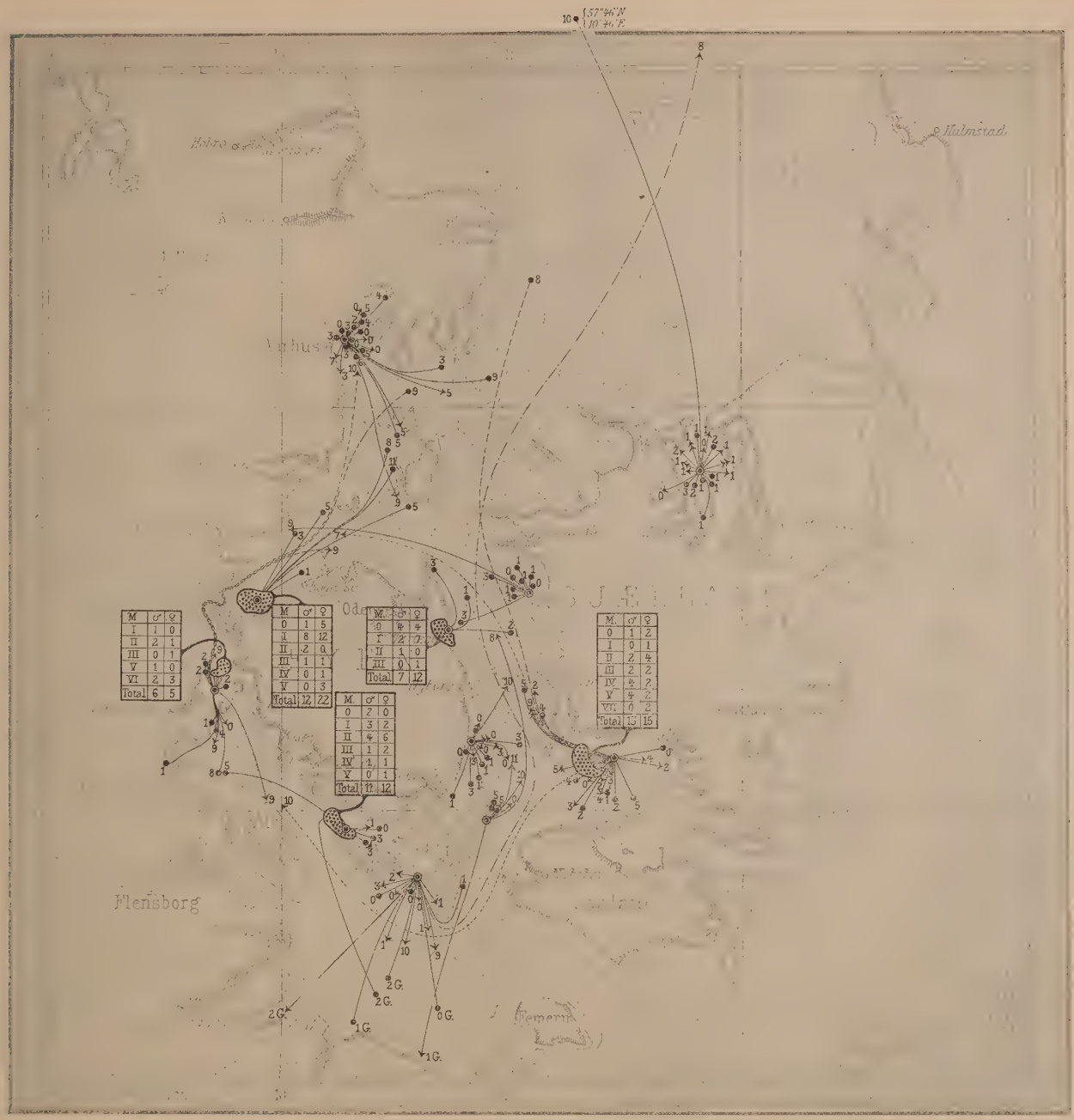


Figure 18. Migrations of marked plaice. Transplanted North Sea plaice. 1933. I.
As to legend see Figure 6.

Figure 19. Migrations of marked plaice. Transplanted North Sea plaice. 1933. II.
As to legend see Figure 6.

M.	♂	♀
0	0	1
I	13	9
II	5	2
III	1	3
IV	2	2
VII	1	1
Total	22	18

M.	♂	♀
0	4	8
I	9	11
Total	13	19

M.	♂	♀
I	3	7
II	3	5
III	0	1
Total	6	13

M.	♂	♀
I	4	3
II	10	13
III	5	5
IV	1	0
V	0	2
VI	0	1
Total	20	24

M	♂	♀
0	3	4
I	10	14
II	8	4
III	6	7
IV	3	1
Total	30	30

M	♂	♀
0	14	7
I	10	10
II	6	7
III	2	1
V	0	1
VI	1	1
Total	33	27

Figure 20. Migrations of marked plaice. Local Belt Sea plaice. 1929. I.
As to legend see Figure 6.

Figure 21. Migrations of marked plaice. Local Belt Sea plaice. 1929. II.
As to legend see Figure 6.

Figure 22. Migrations of marked plaice. Local Belt Sea plaice. 1929. III.
As to legend see Figure 6.

Figure 23. Migrations of marked plaice. Local Belt Sea plaice. 1929. IV.
As to legend see Figure 6.

Figure 24. Migrations of marked plaice. Local Belt Sea plaice. 1931.
As to legend see Figure 6.

Figure 25. Migrations of marked plaice. Local Belt Sea plaice. 1932. I.
As to legend see Figure 6.

Figure 26. Migrations of marked plaice. Local Belt Sea plaice. 1932. II.
As to legend see Figure 6.

Figure 27. Migrations of marked plaice. Local Belt Sea plaice. 1933. I.
As to legend see Figure 6.

Figure 28. Migrations of marked plaice. Local Belt Sea plaice. 1933. II.
As to legend see Figure 6.

1934, lines[1]) being drawn from the places of liberation to the places of recapture by the shortest and most probable way. It is evident that the connecting lines of the two points do not represent the real roads of migration — no doubt the plaice have moved from one place to the other by intricate curves — but the direct lines show the results of their migrations and consequently give a good survey of the main tendency of movements from the various positions of liberation.

It appears distinctly from the charts that the great majority of plaice were recaptured near the areas of liberation. Besides, the main results of the migrations from the individual waters may be worded as follows.

1. Plaice transplanted (Figs. 6—19).

The Baltic.

1928. There is an outspoken tendency in the plaice to emigrate from the Baltic, partly in a northerly direction, partly to the Great Belt; only one specimen has gone eastwards.

The Sound.

1928. The fish liberated at Hornbæk in the Sound showed a marked tendency of migrating in a southward direction. The specimens liberated at Nivaa and Taarbæk — with the exception of two individuals that had migrated into the Kattegat — were recaptured in the Sound.

1929. The migrations principally display a northerly trend, but only 3 of the plaice liberated at Nivaa and Taarbæk were recaptured outside the Sound.

1931. Principally migrations towards the north. All specimens, with 3 exceptions, recaptured within 3 months after their liberation.

1932. All recaptured in the Sound. Only two specimens recaptured 9 and 7 months, resp., after the liberation; the rest taken 4 months after liberation at the highest.

1933. No specimens recaptured outside the Sound, and only 1 taken 10 months after it had been put out; the rest taken 4 months after liberation at the highest.

[1]) For the purpose of distinguishing the individual lines some of them were drawn as full lines, others as dotted or stippled lines.

The Isefjord.

1928. No migrations of importance.

1929. Most specimens recaptured in the Isefjord, only 3 specimens recaptured had migrated into the southern Kattegat.

1931. The greater part recaptured in the Isefjord; 1 had migrated to the southern Kattegat, 1 to the Aarhus Bay.

1932. As earlier; only 3 specimens recaptured in the southern Kattegat.

1933. As earlier; only 2 individuals were recaptured outside the fjord — respectively 3 and 10 months after their liberation.

From Grønne Revle immediately outside the Isefjord 7 specimens had entered the fjord, while 9 specimens had migrated towards the north, east or west.

The Samsø Belt, the Little Belt, the western Baltic, the Smaalandsfarvand and the Great Belt.

1928. The tendency of moving inside the area is more pronounced than that of migrating in a northerly or southerly direction. The most infrequent trend of migration is towards the Baltic; only one specimen (from the Smaalandsfarvand) was recaptured east of Fehmarn.

1929. As in 1928; only 1 plaice (from Bagenkop) recaptured in the Baltic; another from the same locality was taken in the Sound.

1931. As during previous years. 1 plaice recaptured in the Neustädter Bay.

1932. No plaice recaptured in the Baltic. From Nyrup Bay many specimens have entered the Isefjord immediately after their liberation. On the whole but short migrations. In the Little Belt there is possibly a slight tendency of migrating in a northerly direction.

1933. No plaice recaptured in the Baltic. An exceptional amount of plaice marked at Bagenkop were recaptured on the German coast a short time after their liberation.

2. Local Plaice (Figs. 20—28).

The Sound.

1929. The plaice liberated at Hornbæk have principally chosen a northerly route of migration. Of the Nivaa and Taarbæk fish only 3 specimens

were recaptured in the southern Kattegat, the rest in the Sound proper.

1931. No markings of local plaice carried out in the Sound.

1932. All recaptures occurred in the Sound proper and within 5 months after liberation.

1933. 1 specimen recaptured in the Baltic, the rest in the Sound.

The Isefjord.

1929. Only 4 specimens recaptured immediately outside the fjord, the others taken in the fjord proper, principally in shallow water near the coasts shortly after liberation.

1931. No markings of local plaice carried out in the Isefjord.

1932. No markings of local plaice carried out in the Isefjord. From Grønne Revle many plaice have entered the Isefjord.

1933. Only 3 specimens recaptured outside the fjord; otherwise as in 1929.

The Samsø Belt, the Little Belt, the western Baltic, the Smaalandsfarvand and the Great Belt.

1929. No long migrations, but the plaice have moved a good deal inside the area. Only 1 plaice was recaptured east of Fehmarn in the Neustädter Bay.

1931. 1 specimen recaptured in the Baltic off Trelleborg, otherwise as the year before.

1932. No recaptures in the Baltic. From Grønne Revle extensive migrations towards the Isefjord immediately after liberation. Otherwise as previous years.

1933. No recaptures in the Baltic. Otherwise mostly as in previous years.

It is a common feature of all areas and of both local and transplanted plaice that the long migrations mostly take a northerly direction, which is quite a natural thing, for as the plaice grow they will make for deeper water, which is generally found towards the north. Furthermore the migrating plaice will apparently avoid shallow areas with much vegetation, as for instance the waters among the islets south of Funen[1]). It also appears from the charts representing the migrations that the plaice liberated on open coasts will generally spread more than those liberated in inshore waters, a fact which applies to both transplanted and local plaice. Throughout the years there has been a specially vast spreading of plaice liberated at Sejrø (the southern Kattegat) whereas plaice put out in the Isefjord or the Sound have in most cases remained in these waters. Finally, it is an interesting fact that the plaice transplanted to the Little Belt should preferentially make for the deep water in and near the Aabenraa Bay in winter, where they are caught in great numbers (note the numerous recaptures in the months 8—10 on the charts of Figures 8, 9, 13 and 14).

It should be remembered, however, that the recaptures will of course be particularly frequent in places where an intense fishery is carried on; on the other hand this will generally take place in the very localities where plaice gather in large numbers, so that it may be taken for granted that the above mentioned migrations really give a true picture of the movements of the marked plaice.

b. Does any difference exist between the migrations of the transplanted plaice and the local ones?

For the purpose of throwing a light on this problem the waters in which the recaptures took place have been divided into 5 areas marked A, B, C, D and E.

Area A is a local area next to the place of liberation. The individual areas called A are shown in Figure 29. When the hatching of a locality of liberation continues into a neighbouring area, it means that the former overlaps the adjoining locality by a corresponding area.

Area B is all the rest of the transplantation area, limited by the following lines: Fornæs—Kullen, Aflandshage—Klagshamn, Oldenburg Huk (Fehmarn)—Hyllekrog; in 1928, however, by the lines: Hals—Anholt—Kullen and Falsterbo—Kriegers Flak—Dornebusch.

Area C is the water between the northern limit of Area B and the line: Hirshals—Oksø.

Area D is the North Sea and the Skagerak outside Area C.

Area E is the Baltic south and east of Area B.

The subjoined table states how many transplanted and marked plaice have been recaptured within the different areas, partly in per cent.

[1]) On some of the charts, however, the migrations of a few plaice have, by practical reasons, been represented to traverse this area.

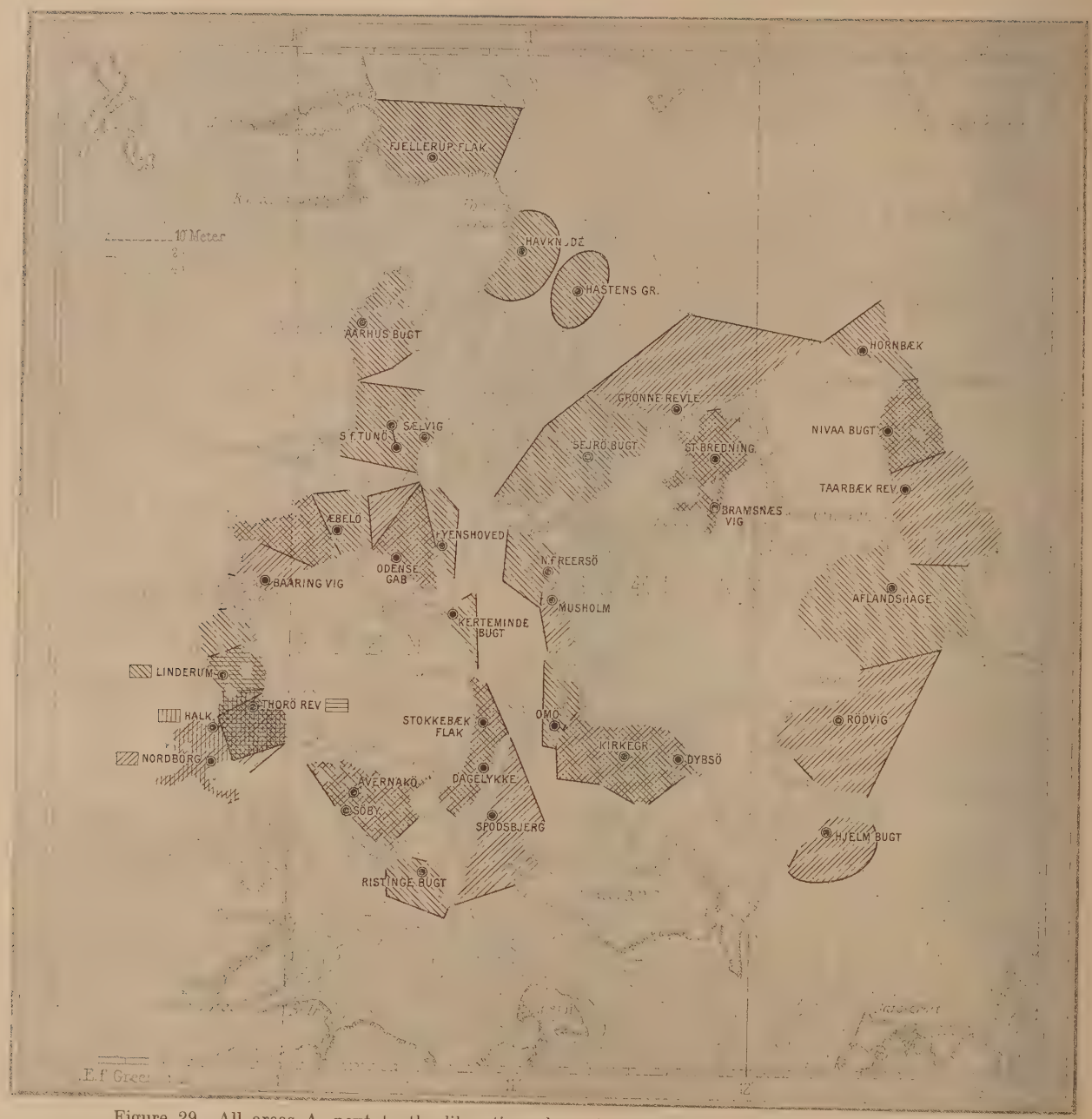


Figure 29. All areas A, next to the liberation places (marked down as circles) of marked plaice.

Figure 30 The long migrations of marked, transplanted North Sea plaice. Signatures as in Figure 6, but at the positions of liberation are further given: year of liberation, sex, and number of months elapsed between liberation and recapture.

of the total number of fish recaptured, partly in absolute figures.

Area	A	B	C	D	E	Total number of individuals recaptured
1928	72.6 %	25.5 %	1.5 %	..	0.4 %	536
1929	79.4 -	19.6 -	0.8 -	0.1 %	0.1 -	883
1931	72.9 -	23.9 -	2.8 -	0.3 -	0.1 -	897
1932	78.2 -	19.5 -	2.0 -	0.3 -	..	642
1933	72.5 -	26.1 -	1.4 -	..	..	434
Average, all years.....	75.1 %	22.9 %	1.7 %	0.1 %	0.1 %	3392
All years, numbers ..	2564	759	59	6	4	3392
All years, calculated in per cent. by numbers	75.6 %	22.4 %	1.7 %	0.2 %	0.1 %	

If we proceed likewise with the numbers of local, marked plaice recaptured within the different areas, we get the following table:

Area.....	A	B	C	D	E	Numbers of individuals
1929	80.9 %	18.3 %	0.7 %	..	0.1 %	1775
1931	78.8 -	20.8 -	..	..	0.4 -	226
1932	80.0 -	19.0 -	1.0 -	..	..	579
1933	86.6 -	12.7 -	0.7 -	..	..	402
Average, all years	81.6 %	17.7 %	0.6 %	..	0.1 %	2982
All years, numbers ...	2425	533	22	..	2	2982
All years, calculated in per cent. by numbers	81.3 %	17.9 %	0.7 %	..	0.1 %	

It will be noted that abt. 75 % of the transplanted plaice were recaptured within the nearest area, A, while 81 % of the local plaice were taken in this area. On the other hand the transplanted plaice caught in Areas B and C outnumbers the local plaice taken in the same areas by 5 and 1 %, respectively. In the North Sea and the Skagerak (Area D) no marked, local Belt Sea fish whatever were recaptured, but 6 marked North Sea plaice were taken here. So there is every indication that the migrations of the transplanted North Sea fish as a whole are somewhat more extensive than those of the local fish. On the other hand it should be duly emphasized that no less than 98 % of the marked North Sea plaice transplanted were recaptured inside the very area of transplantation (Areas A + B). So it is really quite an insignificant part (probably only about 2 %) of the plaice transplanted from the North Sea to the Belt Sea that emigrates from the latter. And moreover a good deal of them are caught by Danish fishermen in the Kattegat, the Skagerak and the North Sea.

c. The long migrations.

The chart Figure 30 gives all the long migrations of the plaice transplanted, that is to say the migrations falling outside the charts of Figs. 6—19.

It is a most striking fact that so large a quantity of marked plaice should be recaptured within one little area on the coast north of the Skaw; it is a matter of 21 marked plaice or half the total of 43

Table 12. Numbers of marked plaice recaptured inside the areas A—D, with statemen

Months (0—12) and years (II, III) after liberation	Area A										Transplant Area B								
	0—3		4—7		8—12		II'		Total		0—3		4—7		8—12		II'		III
Sex	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
1928.....	168	168	20	13	13	2	1	5	202 (51.8 %)	188 (48.2 %)	25	33	11	8	19	18	9	13	..
1929.....	195	337	38	82	12	26	1	10	246 (35.1 %)	455 (64.9 %)	18	35	18	15	27	46	6	7	..
1931.....	224	243	54	72	21	16	13	11	312 (47.7 %)	342 (52.3 %)	17	25	19	29	57	45	8	12	..
1932.....	171	233	34	38	9	12	..	5	214 (42.6 %)	288 (57.4 %)	10	18	14	12	34	19	4	14	..
1933.....	109	134	24	38	6	6	..	..	139 (43.8 %)	178 (56.2 %)	23	32	9	14	19	14	..	1	..
All years...	867	1115	170	243	61	62	15	31	1113 (43.4 %)	1451 (56.6 %)	93	143	71	78	156	142	27	47	..
																			Loc
1929.....	513	617	117	131	11	11	2	33	643 (44.8 %)	792 (55.2 %)	45	52	27	29	75	54	11	31	..
1931.....	104	55	8	1	7	3	..	..	119 (66.9 %)	59 (33.1 %)	23	1	4	1	13	1	4	..	..
1932.....	119	249	19	41	6	12	2	15	146 (31.3 %)	317 (68.7 %)	12	32	4	12	15	21	2	12	..
1933.....	133	172	8	22	4	4	1	4	146 (42.0 %)	202 (58.0 %)	7	14	5	5	10	10	..	..	..
All years...	869	1093	152	195	28	30	5	52	1054 (43.5 %)	1370 (56.5 %)	87	99	40	47	113	86	17	43	..

far-going specimens. In this place an intense fishery is carried on, especially in winter (11 of the plaice recaptured were taken in the months of January and February). The place is crowded with fishing boats working the same locality day by day; though the area be stripped of plaice one day there may be plenties of them the next. Evidently this is a place of migration. As will appear from the chart the 100 m. contour makes a considerable bend southwards just about here. It is well-known that plaice generally avoid depths of more than 100 m. — it will be noted that recaptures mostly occur at depths of far less than 100 m. — and so they are forced to pass this very place close by the coast on their way round the Skaw.

3 plaice were recaptured in the Neustädter Bay in the western Baltic, but only 1 had entered the Baltic proper. 12 specimens were recaptured in the northern Kattegat inside the Skaw, and only 1 of them, which had been carrying its label for no less than 28 months, was taken by Swedish fishermen at Bohuslän. Of the 6 plaice recaptured in the Skagerak and the North Sea no less than 3 originate from the Sejrø Bay, 2 from the Smaalandsfarvand and 1 from Aarhus Bay. The farthest migration amounts to about 370 nautical miles, from the Sejrø Bay to the open North Sea, where a marked plaice was taken by an English trawler. It is of course difficult to estimate the rate of migration on the basis of the information in hand; a plaice liberated in the Sejrø Bay and recaptured 15 months later in the North Sea, 350 nautical miles from the locality of liberation, must have covered at least 0.8 nautical miles per 24 hours.

There are no charts to show the long migrations of the local Belt Sea fish, because only 3 individuals have reached places falling outside the charts of Figs. 20—28. 1 of them was caught at the Skaw in the locality mentioned, and 2 were taken at Læsø.

d. The numerical distribution of males and females in the recaptures. Are the migrations of males and females equally extensive?

Table 12 will help to answer this question in giving the numbers of males and females recaptured in the various areas A—D within definite spaces of time after the liberation.

In appreciating the results it is of course of great importance to see what was the proportion between males and females on the liberation of the marked fish, and so these figures are given in the columns to the right. It will be noted that the females were in the majority in all years with the exception of the local Belt Sea plaice in 1931. As mentioned several times on the preceding pages conditions were in this year extremely difficult as regards the procuring of local fish, and so a sorting was made among the smallest fish in the catches of the fishermen; consequently, the greater part, or 81.5 % of them were males and only 18.5 % females. In fact, this great majority of males among the marked local fish of 1931 is found to appear in the recaptures of these plaice, at any time and in all areas.

Among all the rest of the plaice the females were in the majority, but this prevalence was not equally pronounced every year. The smallest difference was

sex and number of months (0—12) and years (II' and III') elapsed after their liberation.

aice

Total		Area C										Area D								Total of plaice marked and liberated			
		4—7		8—12		II'		III'		Total		8—12		II'		III'		Total					
♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂		♀	
64 (47.1 %)	72 (52.9 %)	..	..	3	..	1	3	..	1	4	4	..	..	..	..	..	..	..	..	1394	48.1 %	1505	51.9 %
69 (39.9 %)	104 (60.1 %)	..	..	4	2	..	1	..	..	4	3	1	..	..	..	..	..	1	..	1007	36.0 %	1792	64.0 %
01 (47.2 %)	113 (52.8 %)	1	..	12	6	1	4	..	1	14	11	..	..	1	1	1	..	2	1	1071	46.6 %	1229	53.4 %
52 (49.6 %)	63 (50.4 %)	..	1	5	5	1	1	..	..	6	7	..	..	1	1	..	..	1	1	864	43.2 %	1135	56.8 %
51 (45.6 %)	61 (54.4 %)	..	..	3	3	..	..	..	..	3	3	..	..	..	..	..	..	..	..	739	39.9 %	1111	60.1 %
47 (45.7 %)	413 (54.3 %)	1	1	27	16	3	9	..	2	31	28	1	..	2	2	1	..	4	2	5167	42.9 %	6880	57.1 %
aice																							
58 (48.4 %)	167 (51.6 %)	..	..	5	4	3	1	..	..	8	5	..	..	..	..	..	..	..	..	1338	44.6 %	1662	55.4 %
44 (93.6 %)	3 (6.4 %)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	693	81.5 %	157	18.5 %
33 (30.0 %)	77 (70.0 %)	..	..	5	1	..	..	..	..	5	1	..	..	..	..	..	..	..	..	320	32.0 %	680	68.0 %
22 (43.1 %)	29 (56.9 %)	..	..	3	..	..	..	..	..	3	..	..	..	..	..	..	..	..	..	438	43.8 %	562	56.2 %
57 (48.2 %)	276 (51.8 %)	..	..	13	5	3	1	..	..	16	6	..	..	..	..	..	..	..	..	2811	47.7 %	3077	52.3 %

found in the transplanted plaice of 1928, when things were closely balanced (51.9 % females as against 48.1 % males), the greatest difference in the transplanted plaice of 1929 (64 % females) and the local plaice of 1932 (68 % females).

If we leave out the figures of the local plaice in 1931 because, as mentioned above, the fish were sorted out for the markings of this year, it appears from Table 12 that on the whole all years exhibit a majority of females in all the areas A, that is to say the areas bordering on the respective localities of liberation, and that they were moreover caught in numbers that were very nearly as high as the proportionate number of females of the corresponding marked stock. In fact, of the marked plaice transplanted the original percentages of females in the years 1928, 1929, 1931, 1932 and 1933 were about 52, 64, 53, 57 and 60 %, respectively; the plaice recaptured in Area A showed the following percentages of females: 48, 65, 52, 57 and 57 %. As regards the local plaice the figures of the years 1929, 1932 and 1933, resp., are as follows: the whole of the stock marked: 55, 68 and 56 %; Area A: 55, 69 and 58 %. These figures give the state of things in Area A as a whole; in the 8th—12th month after the liberation Table 12 shows the distribution of males and females in Area A to be fairly equal, but in the second year after the liberation there is once more a great majority of females in the recaptures of Area A, more particularly among the local fish.

In Area B, the area of transplantation in its entirety, outside Area A, we also find a preponderance of the females in figures corresponding very closely to those given above. But here, too, things are different as regards the fish recaptured in the 8th—12th month, that is to say during the winter half year; in fact there is even a majority of males both among transplanted and local fish. During the second year after the liberation the females are highly predominant, and in the third year after the liberation none but females were recaptured.

If we look at Area C in Table 12, i. e. the Kattegat, we note that in this area the catches principally consist of males. Unfortunately only the figures of the fish recaptured during the 8th—12th month after their liberation are large enough for safe conclusions as to the distribution of sexes; during this period the males are absolutely predominant, even in the years when the females prevailed at most in the original stock of marked fish. However, the fish recaptured during the second and third year after their liberation were mostly females.

The marked fish that were recaptured in Area D — the Skagerak and the North Sea — and the sex of which is known to us are too few in number to permit of conclusions on the distribution of sexes. The same holds good of Area E (the Baltic), which was not included in Table 12.

So we see that while the distribution of sexes among the plaice caught within a short time — 7 months — after their liberation in April was nearly the same as in the stock marked, the females being in the majority, the males prevailed in the catches of the winter season — the 8th—12th month after the liberation in April — a fact which becomes the more distinct, the farther we get away from the places of liberation. There is hardly any doubt that this circumstance is connected with the beginning of sexual maturity in winter. We shall see later that a good deal of the plaice marked became mature already during the first winter after their liberation, but the majority of these individuals were males. The plaice fishery in winter principally works the mature stock of fish at this time of the year emigrating to deeper parts of the waters, and so it is only natural that the males should prevail in the catches of marked plaice at this season; some few of them got as far as the Kattegat on their way towards deeper water. What was said above may be summed up as follows: During the first half year after the liberation the migrations of males and females are of nearly the same extension, and both sexes will principally stay inside the area of liberation; but during the following winter season, when many of the males become mature, the migrations of the latter are longer than those of the females, and although most of them will remain in the area of transplantation, some few will go northwards towards deeper water for the purpose of spawning.

It must be considered an advantage that the fish transplanted do not stray too wide about, and so the fish to be transplanted should by preference be taken from stocks that are principally composed of females.

e. The seasonal migrations to shallower and deeper water.

It is a well-known fact that the plaice carry out seasonal migrations, in spring making for shallow water and in winter for the deeps. If we calculate the average depth in which the marked plaice were recaptured in each month of the year, we find that found average depths have a very characteristic course. Immediately after they have been put out in April the plaice will leave the areas of liberation, where there is generally a depth of 10—20 m., and make for the shallow coastal water. By the way, the same fact appears from the charts of Figs. 6—28, showing the migrations. In April the average depth

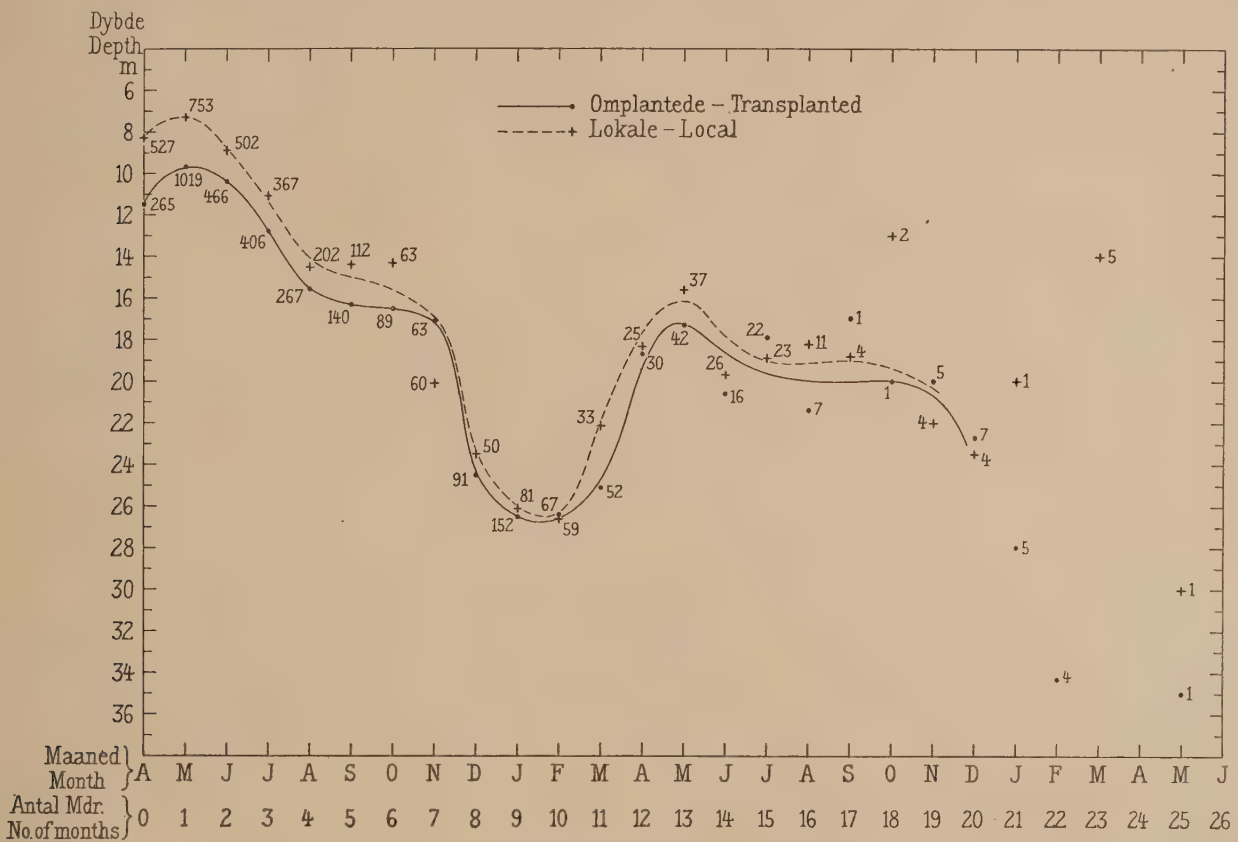

Dybde
Depth
m
Omplantede – Transplanted
Lokale – Local
Maaned
Month
Antal Mdr.
No. of months
A M J J A S O N D J F M A M J J A S O N D J F M A M J
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

Figure 31. Average depths in catching places of marked plaice recaptured inside the area of transplantation and calculated per month after the liberation in the years 1928—29 and 1931—33. The figures affixed to the curves state the numbers of fish recaptured.

these conditions, too, hold good of both the transplanted and local representatives of marked plaice.

In Figure 31 above the average depths of the catching places are stated by the month by means of points or crosses for respectively transplanted and local plaice recaptured in the area of transplantation south of the line Fornæs—Lysegrund—Gilleleje Light-ship—Kullen. The figures affixed state the number of fish recaptured in each separate month after their liberation.

It will be seen that the graphs connecting the of the localities, in which the fish transplanted were recaptured, was 11.5 m., in May only 9.7 m. But already in June the migration into deeper water begins, and it is continued in July and August when the average depth is abt. 15 m. At this time of the year there is some flattening of the graph, the average depths of September and October not increasing very much, but from November there is once more a rapid decline of the graph, the average depth being abt. 24 m. in December and more than 26 m. in January. Many of the fish recaptured are

now mature. From February onwards the graph rises steeply, and in May the average depths are 16—17 m. During the second year after the liberation the graph shows much the same course as the year before, having a rapid fall from May till July, a nearly horizontal course from August till October and another decline from the month of November. But the graphs of both transplanted and local plaice are running on a somewhat lower level than in the previous year. So it seems that the plaice live in deeper water the older they grow. But the seasonal migrations are still very distinct.

It will be noted that on the whole the graph of the transplanted plaice runs somewhat lower than that of the local fish, which seems to indicate that the majority of the former prefer to live in somewhat deeper water than the latter.

Accordingly, we may lay down the following facts: immediately after their liberation in April the majority of both transplanted and local individuals of marked plaice, make for the shallow coastal waters (average depth in May 7.3 and 9.7 m., respectively, for local and transplanted fish), and during the months of June, July and August they gradually migrate into depths of about 15 m. In these intermediate depths they remain in September and October as well, but during the period from November till January they will emigrate into still deeper water, a good deal of them for the purpose of spawning here, in depths between 20 and 30 m. In the course of March, April and May they start once more for the shallow water near the coasts, the smallest average depth, however, of the second year after the liberation being 16—17 m. (in May). The summer of the second year is spent in depths of about 19—20 m., and in November, like the year before, the plaice will once more go into deeper water for the purpose of spawning.

On the whole the plaice transplanted seem to live in somewhat deeper water than the local Belt Sea fish.

f. Do the plaice transplanted breed in the area of transplantation?

This question is of course of very great importance in judging the effects of the transplantations. If a great deal of fish transplanted are spawning in the area of transplantation they will bring the native stock a rather considerable supply of eggs and fry. It is difficult to define the importance of this question; there are many evidences that on account of the prolificness of the plaice there has as yet never been any want of eggs and tiny fry in the Belt Sea waters although the spawning stock has been established to be very few in number. A far greater importance must be ascribed to the physical and biological conditions of the sea: temperature and currents and nourishment during the development of eggs and fry; if these conditions are unfavourable, the number of eggs spawned is indifferent, and the stock of fry in that year will in all cases be small.

On the other hand it is just possible that the local stock of plaice in the Belt Sea waters, which is known to be worked most intensely even during the spawning time, may be decimated to such a degree, that a want of mother fish will ensue. The long series of poor brood years in the Belt Sea in the years before 1932 would seem to indicate that such a state of things had already set in during the years before the beginning of the transplantations; at all events there is no harm done in adding to the numbers of eggs and fry in the Belt Sea. Furthermore, the North Sea fish are known to be racially distinct from the Belt Sea fish, and it will no doubt be worth while to bring in this foreign element with its excellent racial characters: hardiness, rapid growth, etc. Finally, if the fish transplanted remain in the areas in which they have been liberated and do not leave them for the purpose of spawning, it is a proof of their feeling extremely well there. Other kinds of fish, which properly live in more northern waters, as for instance haddock and coal fish, sometimes, when young, spend two or three years on end in the Belt Sea waters, where large quantities of them are observed to thrive well, but they have been found to leave this area again when they arrive at the stage of maturity.

In the subjoined Tables 13 and 14 is given any information gathered on the stage of maturity of the marked plaice recaptured inside the area of transplantation (Area A + B). Only such fish as were sent directly to the Biological Station could possibly be determined as to their stage of maturity; they constitute but a minor part of the whole material, but are numerous enough to give us a good

Table 13. Local marked plaice caught inside the area of transplantation; stage of maturity stated.

Number of months after liberation		1 Mj.	2 Jn.	3 Jl.	4 Au.	5 S.	6 O.	7 N.	8 D.	9 Ja.	10 F.	11 Mr.	12 Ap.	13 Mj.	14 Jn.	15 Jl.	19 N.	33 Ja.	Total ♂	Total ♀
Immature	♂	28	1	1	..	..	..	..	..	..	..	1	..	1	..	..	..	..	32	
	♀	27	3	1	1	..	2	1	..	2	5	4	3	2	9	1	..	..		61
M. I	♂	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
	♀	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..		2
M. II	♂	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	2	
	♀	..	1	..	..	..	1	2	..	3	1	1	2	8	..	..	..	..		19
M. III	♂	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
	♀	..	..	..	..	1	1	..	..	..	..	..	1	..	..	..	..	..		3
M. IV	♂	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	2	
	♀	..	..	..	..	..	1	..	1	2	..	..	..	..	1	..	1	..		6
M. V	♂	..	..	..	..	1	..	3	5	8	2	..	..	..	..	..	..	..	19	
	♀	..	..	..	..	..	..	..	2	4	1	1	..	..	..	..	..	..		8
M. V—VI	♂	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	2	
	♀	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		..
M. VI	♂	..	..	..	..	..	..	..	..	3	7	2	1	..	..	..	..	..	13	
	♀	..	..	..	..	..	..	..	..	3	3	1	..	..	..	..	..	1		8
M. VI—VII	♂	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
	♀	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..		1
M. VII (spent)	♂	..	..	..	..	..	..	..	..	..	2	..	1	..	..	..	..	..	3	
	♀	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..		1
Total...		55	5	2	1	2	6	6	12	28	22	10	9	11	10	1	1	1	73	109
																			182	

Table 14. Transplanted marked plaice caught inside the area of transplantation; stage of maturity stated.

Number of months after liberation		1 Mj.	2 Jn.	4 Au.	5 S.	6 O.	7 N.	8 D.	9 Ja.	10 F.	11 Mr.	12 Ap.	13 Mj.	14 Jn.	15 Jl.	16 Au.	19 N.	20 D.	21 Ja.	22 F.	Total ♂	Total ♀
Immature	♂	2	2	2	2	2	..	1	3	4	3	..	5	..	1	..	..	..	..	..	27	
	♀	5	2	7	2	5	2	9	20	14	10	6	7	6	..	..	..	1	2	..		98
M. I	♂	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
	♀	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..		1
M. II	♂	..	..	..	..	1	..	1	..	1	..	1	..	..	..	..	..	..	..	..	4	
	♀	..	..	..	..	2	1	2	10	2	..	1	1	..	..	1	..	..	..	..		20
M. III	♂	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	2	
	♀	..	..	..	..	..	1	2	1	..	..	..	..	..	1	1	..	..	..	..		6
M. IV	♂	..	..	..	..	1	1	2	4	1	1	..	..	..	..	..	..	..	..	..	10	
	♀	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..		2
M. V	♂	..	..	..	..	..	2	5	11	6	..	..	..	..	..	..	3	..	..	..	27	
	♀	..	..	..	..	..	..	..	3	1	..	..	..	..	..	..	..	2	..	3		9
M. V—VI	♂	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	2	
	♀	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1	..		2
M. VI	♂	..	..	..	..	..	..	5	11	3	2	..	..	1	..	..	..	..	1	1	24	
	♀	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1		2
M. VI—VII	♂	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	
	♀	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		..
Spent	♂	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
	♀	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..		2
Total...		7	4	9	4	11	9	27	67	35	18	8	14	7	2	2	3	3	4	5	97	142
																					239	

Table1 5. The proportion of mature and immature fish among the marked plaice recaptured in the months of October—March inclusive.

		1. spawning period, 6—11 months after liberation				2. spawning period, 18—22 months after liberation				3. spawning period, 33 months after lib.		Total			
		♂		♀		♂		♀		♀		♂		♀	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Transplanted Plaice	Immature....	16	21.6	78	88.6	0	0	3	30	..	..	16	20.3	81	82.7
	Mature	58	78.4	10	11.4	5	100	7	70	..	..	63	79.7	17	17.3
Local Plaice	Immature....	3	7.7	24	54.5	..	..	..	..	..	..	3	7.7	24	52.2
	Mature	36	92.3	20	45.5	..	..	1	100	1	100	36	92.3	22	47.8

idea of the distribution of the maturity stages throughout the different months.

The tables show that all the plaice recaptured in the first months were immature, — quite a natural consequence of the fact that all the fish marked were immature when liberated in April. It is not until the month of September that two specimens of the local Belt Sea stock (Table 13) are noted to have reached the maturity stages III and V. From October and throughout the autumn and winter months the number of mature plaice increases, but there are still some immature individuals left, especially among the females. After the month of March only few fish could be stated as mature; such fish do not reappear until the second winter, and at this time very few plaice are immature.

It appears distinctly from Table 14 that several of the plaice transplanted become mature in the areas of transplantation already during the first winter. The numerical expression of this fact was put down in Table 15 after it had been calculated by Tables 13 and 14 how many mature and immature plaice occurred in the 6th to 11th and the 18th to 22nd month, these months, October to March inclusive, being the only ones in which you could safely tell whether a plaice is mature or will become so during the spawning period in question. Besides the plaice given as immature in the table also the maturity stages I and II were classed among the immature fish. The plaice of stage III were left out because we cannot say for certain whether or not fish of this stage will become mature in the immediate future; by the bye this category only includes 1 individual in Table 13 and 5 individuals in Table 14 during the months of October to March. Among the mature fish were classed the maturity stages IV—VII and the individuals characterized as "spent" in the tables.

It will be seen from table 15 that already during the first spawning period, that is to say the first winter after their liberation, a very large percentage (78.4 %) of the males of the transplanted plaice

Table 16. Stages of maturity (I—VII) in transplanted North Sea fish

	Date	$^{31}/_{10}$ 1931	$^{27}/_{10}$ 31	$^{22}/_{10}$ 31	$^{17}/_{11}$ 31	$^{17}/_{10}$ 31	$^{25}/_{11}$ 31	$^{27}/_{11}$ 31	$^{26}/_{1}$ 32	$^{25}/_{1}$ 32	$^{29}/_{1}$ 32	$^{6}/_{2}$ 32	$^{2}/_{2}$ 32	$^{21}/_{2}$ 32	$^{21}/_{3}$ 32
	Locality	Aarhus Bay	NE. of Als	W. of Samsø	W. of Musholm	Isefjord	TheSound, 15 m.	Ristinge Bay, 17 m.	W. of Bagenkop	Aabenraa Fjord	NE. of Als	Aarhus Bay	W. of Fyns-hoved	Smaa-landshav.	W. of Samsø,
♂♂	I—II	2	..	4	..	1	..	..	..	3	..	..	..	1	2
	III	..	1	..	..	..	..	..	..	..	..	..	..	..	..
	IV	1	1	2	2	1	..	..	..	..	..	..	..	..	..
	V	..	2	..	3	..	5	2	..	3	..	..	..	..	..
	VI	..	..	..	..	..	..	..	2	9	1	2	..	..	..
	VII	..	..	..	..	..	..	..	..	..	..	..	..	..	..
♀♀	I—II	5	2	6	5	4	2	2	..	8	1	3	1	..	2
	III	..	..	..	1	..	..	..	..	..	..	..	..	..	..
	IV	..	2	4	..	3	1	2	..	..	..	..	..	..	..
	V	..	..	..	..	..	1	5	1	1	1	..	..	..	1
	VI	..	..	..	..	..	..	..	1	1	..	..	..	..	..
	VII	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Total...	8	8	16	11	9	9	11	4	25	3	5	1	1	5

examined were found to be mature; in the second winter after their liberation all of them were mature. However, a good many females were still immature in the first winter; only 11.4 % of the plaice examined spawned during this period, but during the next winter 70 % of the females examined were spawning. According to this calculation, a total of 79.7 % of the transplanted males and 17.3 % of the females spawned inside the area of transplantation.

The number of mature individuals among the local fish examined was much larger. During the first spawning period 92.3 % of the males and 45.5 % of the females were found to spawn. During the second and third spawning period only few fish were examined; they were all mature.

We may then put down as the principal result of this examination of the stage of maturity of the marked plaice recaptured that more than one sixth of the female and no less than four fifths of the male plaice transplanted arrive at maturity inside the area of transplantation.

In view of corroborating these figures I have in Table 16 made up such results of analyses on the maturity in the North Sea fish transplanted as were arrived at during the race- and age-investigations (see Chapter III B, p. 75) of random samples of the catches of fishermen inside the area of transplantation. Here, too, only those months (October to March incl.) were considered in which the stage of maturity will allow us to conclude whether the fish are going to spawn or have spawned during the period in question.

The righthand column of Table 16 was made up in the same way as in Table 15 and shows that of 100 males examined 74 specimens and of 157 females 50 specimens or 32 % were mature. The figures give a somewhat higher percentage of mature females and a slightly smaller percentage of mature males than Table 15, but the range of size of the figures is fairly even in both tables.

Although the two results were achieved on the basis of totally different material, they agree so well, that there can be no doubt of their correctness, both series of investigation showing that a very large percentage of the males and a considerably smaller percentage of the females transplanted arrive at maturity inside the area of transplantation. Accordingly, we may reckon from 17 to 32 % of the female and from 74 to 80 % of the male plaice transplanted to become mature in the transplantation area. We shall hardly need to point out the significance of these figures; in fact, the transplantations of North Sea plaice must be supposed to bring about a rather considerable increase of the quantities of eggs and fry.

It may be added here that A. R. Molander ("Über das Vorkommen der jüngsten Altersgruppen der Scholle etc." Rapp. et Procès-Verb., Vol. 94, 3. Partie, p. 35) has been able to explain

m the catches of fishermen in the Belt Sea waters in 1931—34.

3	16/3	17/1	24/1	1/2	31/1	3/3	16/11	22/11	27/11	5/12	14/12	15-16/2		
2	32	33	33	33	33	33	33	33	33	33	33	34		
Sound, 17 m.	N. Great Belt, 20 m.	SW. of Gulstav	at Reersø, 30 m.	W. of Samsø, 33 m.	Aabenraa Fjord	Aarhus Bay	Aabenraa Fjord	Lohals	N. Great Belt	Aabenraa Fjord	S. Great Belt	E. of Tunø	Total	Number
.	3	1	..	1	1	1	1	..	1	2	1	1	26	immature: 26 = 26 %
.	..	..	..	..	..	..	..	..	..	..	..	..	1	
.	..	..	..	..	..	..	..	1	1	..	..	..	9	
.	..	..	1	..	5	..	..	..	1	7	2	..	31	mature: 74 = 74 %
.	..	1	6	2	6	1	..	..	1	2	..	1	34	
.	..	..	..	..	..	..	..	..	..	..	..	..	0	
3	1	2	3	10	11	3	13	..	4	8	..	8	107	immature: 107 = 68 %
.	..	..	..	..	..	..	..	..	..	..	..	..	1	
.	..	..	..	..	..	..	..	..	..	6	..	..	18	
.	..	1	..	..	5	2	..	..	..	9	1	..	28	mature: 50 = 32 %
.	..	..	..	..	1	..	..	..	..	..	..	..	3	
.	..	..	..	..	..	..	..	..	..	..	..	..	1	
:	4	5	10	13	29	7	14	1	8	34	4	10	259	

Table 17. Average growth increment in transplanted, marked plaice from liberation to the month of recapture during the years 1928—1933.

Recaptured number of months after liberation		1928		1929		1930		1931		1932		1933		Total	
		No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.
0	Apr.	13	0.0	39	0.3	7	0.3	51	0.5	73	0.2	56	0.3	239	0.3
1	May	205	0.3	286	0.4	27	1.4	212	0.5	115	0.5	87	0.8	932	1.1
2	Jun.	60	1.1	129	2.3	24	2.8	84	1.8	83	1.9	57	2.4	437	2.0
3	Jul.	45	3.4	101	4.2	6	1.8	93	4.0	89	4.1	53	4.3	387	4.0
4	Aug.	17	4.9	62	5.5	5	3.5	88	5.7	60	5.6	28	6.2	260	5.6
5	Sept.	9	7.3	40	8.2	..	..	35	6.7	17	7.4	40	6.5	141	7.2
6	Oct.	14	9.3	26	9.7	..	..	27	7.9	10	9.0	10	7.3	87	8.8
7	Nov.	1	8.0	21	10.9	..	..	20	11.3	14	10.9	5	9.9	61	11.0
8	Dec.	8	9.9	15	11.6	1	2.5	37	11.8	22	11.6	14	11.2	97	11.7
9	Jan.	19	10.4	47	12.1	..	..	53	11.7	28	12.3	21	11.7	168	12.2
10	Feb.	1	16.0	26	12.3	..	..	30	11.9	14	12.0	13	11.9	84	12.0
11	Mar.	8	8.8	10	12.0	..	..	17	11.7	14	13.2	4	12.8	53	11.6
12	Apr.	13	9.5	12	12.5	1	10.0	8	12.3	3	11.0	3	10.0	40	11.2
13	May	7	11.2	11	12.4	..	..	13	13.6	5	13.5	4	11.0	40	12.4
14	Jun.	3	14.0	6	14.6	..	..	8	12.3	5	13.3	..	..	22	13.3
15	Jul.	3	11.8	3	15.8	..	..	9	14.6	7	14.9	..	..	22	14.6
16	Aug.	3	13.3	3	17.5	..	..	..	..	1	16.5	..	..	7	15.5
17	Sept.	..	..	..	..	1	17.5	..	..	1	17.0	..	..	2	17.3
18	Oct.	1	16.0	..	..	..	..	..	..	1	14.5	..	..	2	15.3
19	Nov.	1	14.5	..	..	..	..	4	17.0	2	14.3	..	..	7	15.9
20	Dec.	..	..	3	18.2	..	..	1	18.5	3	17.8	..	..	7	18.0
21	Jan.	2	15.3	..	..	..	..	4	18.0	1	14.0	..	..	7	16.7
22	Feb.	1	16.0	..	..	..	..	2	20.0	1	22.0	..	..	4	19.5
	Total...	434		840		72		796		569		395		3106	

Table 18. Average growth increment in marked, local plaice, from liberation to the month of recapture during the years 1929 and 1931—1933.

Recaptured number of months after liberation		1929		1931		1932		1933		Total	
		No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.
0	Apr.	194	0.3	..	..	111	0.3	72	0.3	377	0.2
1	May	447	0.6	50	0.4	97	0.6	101	0.4	695	0.6
2	Jun.	305	1.5	26	0.6	86	1.4	58	0.9	475	1.5
3	Jul.	209	3.2	15	1.2	73	2.5	37	2.0	334	2.8
4	Aug.	124	4.8	16	2.2	45	3.9	17	3.2	202	4.3
5	Sept.	81	6.0	5	4.4	14	4.0	9	4.6	109	5.6
6	Okt.	35	7.4	4	4.9	12	5.8	10	5.4	61	6.6
7	Nov.	47	8.4	2	8.0	5	7.2	3	6.2	57	8.2
8	Dec.	22	8.3	4	4.5	17	7.4	7	5.0	50	7.3
9	Jan.	50	8.7	2	5.3	21	6.8	8	7.3	81	8.0
10	Feb.	47	8.6	9	5.8	11	7.7	4	6.3	71	8.0
11	Mar.	19	8.7	4	6.6	7	8.8	5	7.6	35	8.2
12	Apr.	16	9.7	3	5.5	3	9.5	4	6.6	26	8.6
13	May	24	10.4	4	6.4	7	8.7	3	6.5	38	9.6
14	Jun.	21	10.5	2	4.1	4	6.8	1	8.0	28	9.5
15	Jul.	18	11.2	1	7.5	5	10.2	..	..	24	10.7
16	Aug.	6	13.0	..	..	3	7.7	..	..	9	11.2
17	Sept.	1	16.5	..	..	3	10.2	..	..	4	11.8
18	Oct.	2	10.0	..	..	..	..	..	..	2	10.0
19	Nov.	3	13.7	..	..	1	13.0	..	..	4	13.5
20	Dec.	4	14.4	..	..	..	..	..	..	4	14.4
21	Jan.	1	9.5	..	..	..	..	..	..	1	9.5
	Total...	1676		147		525		339		2687	

the cause of unusually large quantities of plaice fry appearing on the Swedish coast of the southern Kattegat in 1933—34 in one way only: the Danish transplantations have augmented the numbers of mother fish and consequently of eggs and fry in these waters.

D. The growth of the marked plaice.

a. The growth of the plaice transplanted as compared with the growth of the local stock.

It was previously stated that the numerous markings of plaice were carried out among other things for the purpose of procuring a material by which to judge and compare the growth of the transplanted and the local plaice. It will be remembered that on their liberation the marked fish of the two categories had nearly the same length, 20—25 cm., the average length being 22.4 cm. (see p. 23).

Examinations of the recaptured plaice have in a most satisfactory way contributed towards the solution of the problems mentioned above. For although some information regarding the length of the plaice on the recapture has been lost on account of the fisherman's forgetting to measure the fish or his putting it out again that it might live to grow larger, by far most of the fish recaptured have been given over to the Fisheries Inspectorate or forwarded to the Biological Station. Reliable figures concerning the growth in length from liberation till recapture amount to a total of 3106 specimens of transplanted North Sea plaice and 2687 plaice of the local stock.

The distribution of the 3106 recaptures from the transplantations is put down in Table 17, which also gives the average increment of growth from liberation to the month of recapture.

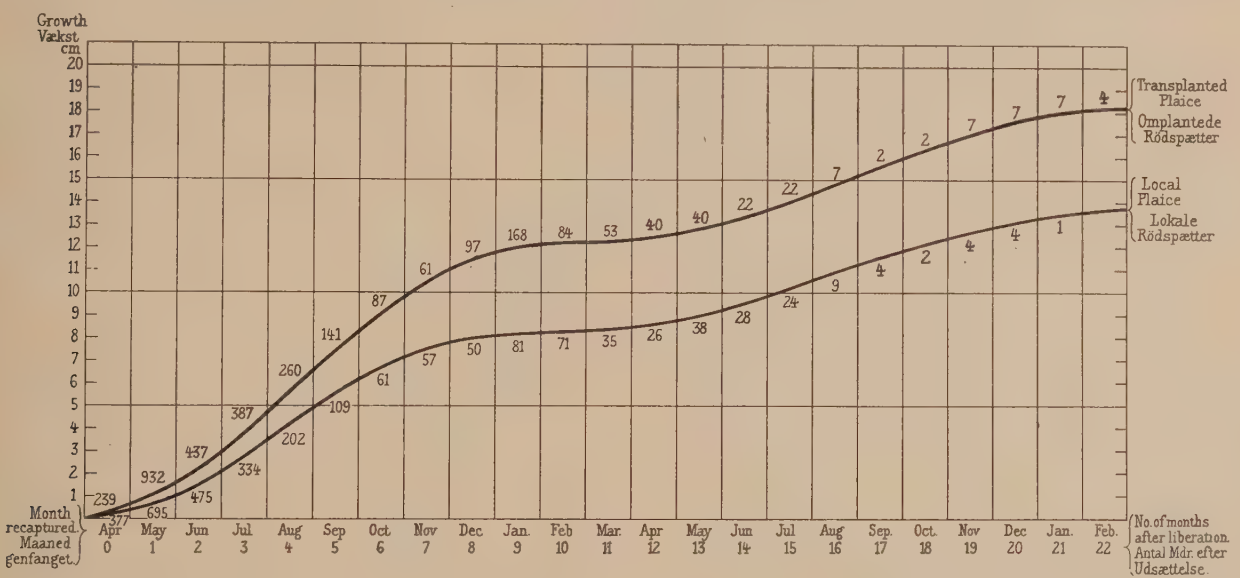

Growth
Vækst
cm
Transplanted Plaice
Omplantede Rödspætter
Local Plaice
Lokale Rödspætter
Month recaptured
Maaned genfanget
No. of months after liberation.
Antal Mdr. efter Udsættelse.
Apr May Jun Jul Aug Sep Oct Nov Dec Jan. Feb Mar. Apr May Jun Jul Aug Sep. Oct. Nov Dec Jan. Feb.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

Figure 32. Curves showing the average growth in transplanted and local plaice during the years 1928—1933. The figures denote the numbers of individuals measured.

Table 18 states the distribution of the 2687 recaptures of local Belt Sea plaice and the growth increment per month of these plaice.

It appears from Tables 17 and 18 that reliable information of the marked plaice recaptured extends over 22 months after the liberation of the fish. And although far too large (abt. half) a number of the items of information originate from the first few months after the liberation, we have still a sufficient material for a calculation of the average growth month by month.

Figure 32 shows the average growth of transplanted and local plaice, calculated by the statements of growth mentioned above. The graphs were

smoothed taking into account the number of individuals measured in the individual cases. It will be noted that they are in close accord with the growth curves previously published in the papers of the author (**1932**, **1933**), and so we see that the surprisingly rapid growth of the transplanted North Sea fish as compared with the local stock of the Belt Sea has continued throughout the years. This is one of the most conspicuous and significant results of the experimental transplantations.

The curve of the transplanted North Sea plaice shows that these fish do not grow very rapidly immediately after their transplantation in April, but from June, when they have acclimatized, their growth begins to quicken; it culminates in autumn, continues in the months of November and December and has brought about an increase in length of about 12 cm. in January. The graph representing the growth of the local stock has a more regular course. It rises smoothly to an increase of abt. 8 cm. in January (9 months after the liberation). During the winter months there is a stagnation of growth, but in April a new growth period begins, which may be characterized as the growth period of the second year after the liberation. The graph representing the growth during the second year after the liberation rises smoothly to an increase of abt. 18 cm. for transplanted and of abt. 13.5 cm. for local plaice.

In other words, during the growth period of the second year the transplanted fish have increased in size by only half, and the local fish by little more than half the increment of the growth period of the first year. This is no doubt quite a normal thing, for it is well-known that from the third or fourth year of life the rate of growth of stationary plaice declines with the increasing age. That the growth of the local fish during the growth period of the second year is comparatively quicker than the growth of the fish transplanted must no doubt be ascribed to the fact that the local Belt Sea plaice were only 2 or 3 years old on their liberation, the transplanted fish, however, being mostly from 4 to 6 years old.

At the beginning of the growth period of the second year the length of the plaice transplanted averaged 35 cm., the local fish at the same time showing a mean length of 31 cm. In spite of this considerable difference of the average sizes the absolute growth increment of the fish transplanted was larger than that of the local fish also during the growth period of the second year, which must be characterized as a very good result, more particularly in view of the fact that the weight increase of the former was comparatively much higher than that of the latter.

All these facts given there can hardly be any doubt that the quicker growth of the North Sea plaice is a consequence of the North Sea race having a higher "potential growth energy" than the Baltic race, that is to say that plaice of the North Sea race, other things equal, will grow more rapidly than plaice of the Baltic race. In other words, the poor growth of the Horns Reef plaice before the transplantation (in the Horns Reef area they will only grow by 2 to 5 cm. a year) is due to poor conditions of nutrition, which again are caused by the overpopulation of this locality; as soon as the plaice are removed to localities with good conditions of nutrition, their latent growth energy will come to development and manifest itself in a growth that exceeds by far that of the local Belt Sea stock, in spite of the latter having spent the whole of its life under good conditions of nutrition.

b. The growth of the plaice in the different years.

1. The growth of the plaice transplanted.

The graphs of Figure 33 represent the average growth of plaice transplanted in each of the years 1928—29 and 1931—33. The material, on which these graphs are based, was already given in Tables 17 and 18. The graphs have been smoothed taking into account the number of individuals measured. The year 1930 was not included, the individuals recaptured in this year after the 4th month being too few in number.

It appears from the graphs that the differences of growth from year to year are small. 1928 is the only exception, the growth of this year being on the whole somewhat inferior to that of the rest of the years. It should be remembered, however, that in this year a great part — abt. two thirds — of the fish to be transplanted were taken from the Nissum Broad and the Thyborøn. It was formerly pointed out that these Limfjord fish were carried by well-smacks from the Limfjord directly to the places of liberation without being formerly kept for some time in well-boxes; furthermore they were much smaller than the plaice from the Horns Reef area, and so it is not unlikely that many of them should have some difficulty in recovering from the long transport

during the first time after the liberation. It must be kept in mind, too, that 1928 was the first year in which these transplantations were attempted; so we lacked the experience of later years as regards keeping and transport of the fish, and there is hardly any doubt that this has influenced the growth of the fish. A fish put out may well seem to be likely to live, but if it is in a state of debility and exhaustion from the handling during its being fished, kept and transported, it will of course not be able to match the growth of completely fresh fish — at any rate not during the first time after its liberation.

As regards the remaining years it may be mentioned that on the whole the curve of the year 1929 seems to run somewhat higher than those of the remaining years; especially the growth during the second year after the liberation would seem to be somewhat more rapid than was the case with the marked fish

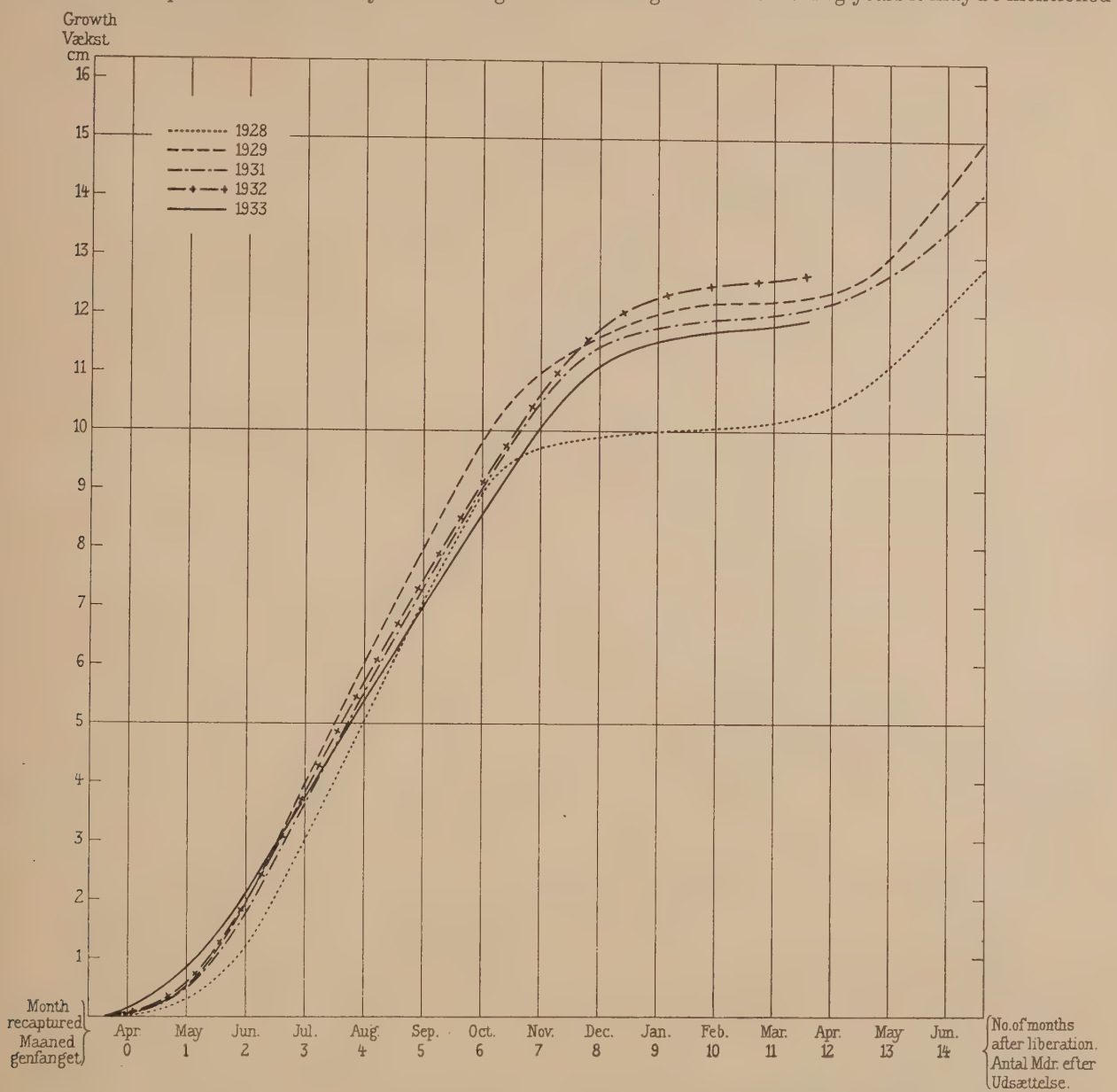


Figure 33. Growth curves of the marked plaice transplanted in the years 1928—33.

transplanted in the other years. Otherwise the graphs show much the same course. The principal result is that the year 1928 exhibits a decidedly slower growth than the following years, the growth curves of which are much like each other.

in 1931 were males (see p. 59), the growth of which, as is well known, is somewhat slower than that of the females. The graphs of 1932 and 1933 run together during the first months, but from October the former year is somewhat in advance.

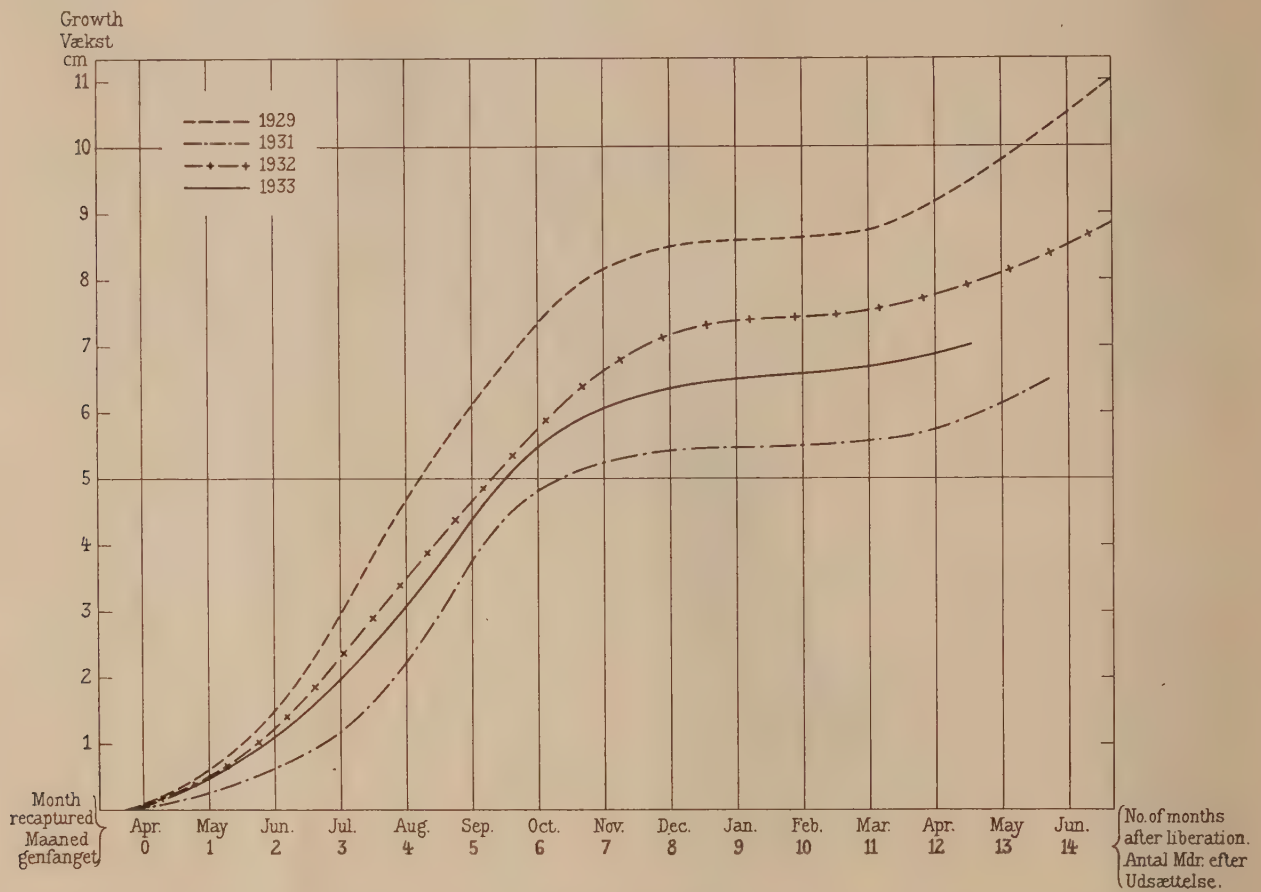


Figure 34. Growth curves of the local Belt Sea plaice marked and liberated in the years 1929 and 1931 to 33.

2. The growth of the local plaice.

The growth curves of the local fish are given in Figure 34, which represents the average growth during the years 1929 and 1931 to 33. Here, too, the curves were smoothed taking into account the number of individuals examined.

It is remarkable that the growth curves of the local Belt Sea fish are much more unlike each other than those of the transplanted North Sea fish. The year 1929 exhibits by far the quickest growth of the marked local fish while the growth of the year 1931 is somewhat inferior to that of the years 1932 and 1933, no doubt because most of the local fish liberated

c. The growth of the plaice in the various areas of transplantation.

For the purpose of possibly establishing a difference of growth in both transplanted and local plaice inside the different areas of transplantation the graphs of Figs. 35 and 36 were drawn as to represent the average growth of the marked plaice liberated in these areas; the graphs were smoothed in a similar way to that of Figs. 33 and 34. These graphs base on the material given in Tables 19 and 20.

It should be remembered that although a large percentage of the marked plaice were recaptured inside the area in which they had been liberated,

many individuals have grown up in other areas, and so, properly, the graphs can only show which of the plaice, liberated in the different areas, have been growing most rapidly.

Here, too, it will be noted that generally speaking the growth of the plaice transplanted has been more

Belt Sea fish (Figure 36) also testify to a better growth of the fish put out in the Smaalandsfarvand, the water NW. of Seeland and the Great Belt, a somewhat slower growth of the fish from the Little Belt and Ærø, and the poorest growth of the fish liberated north of Funen. In contrast to the trans-

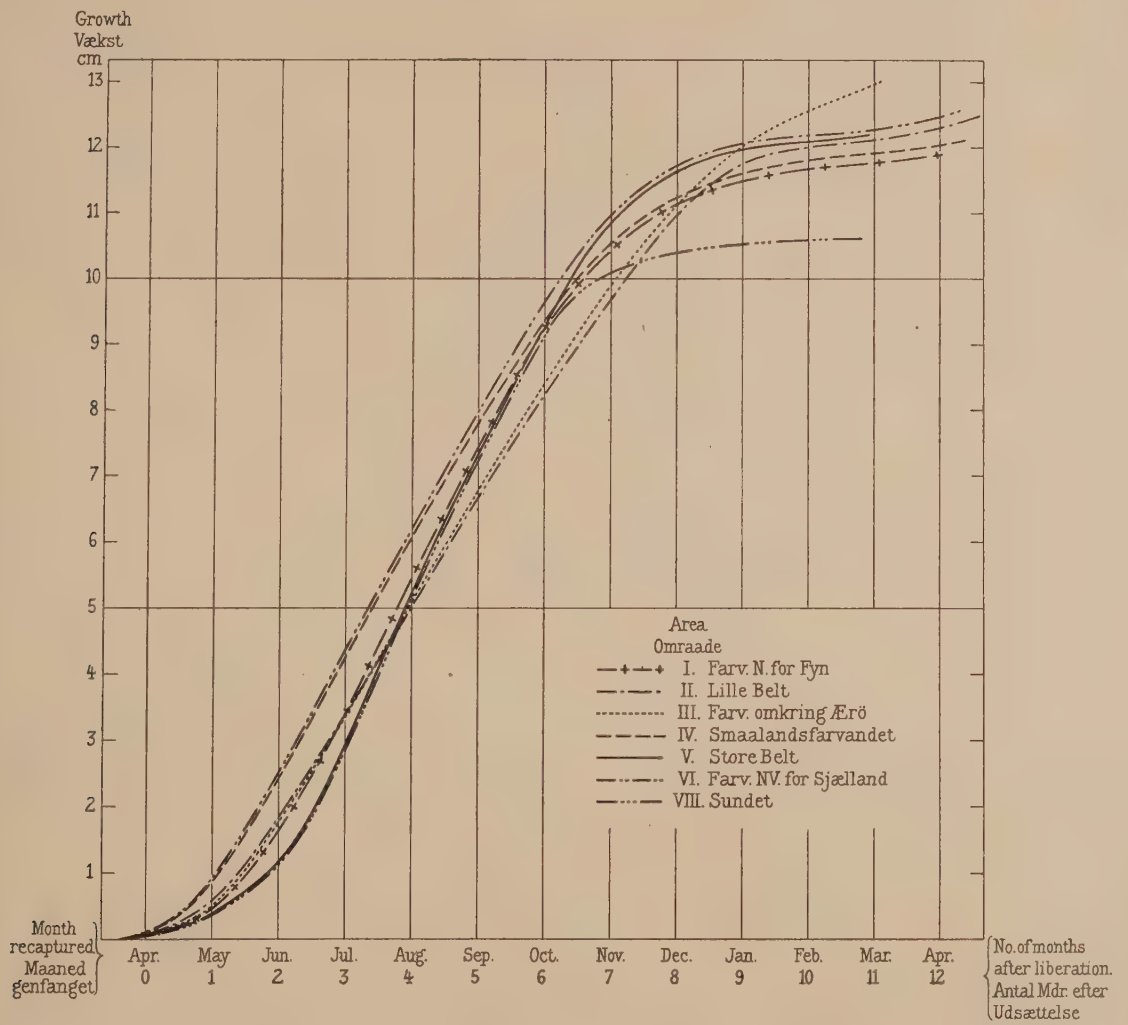


Figure 35. Growth curves of the marked North Sea fish liberated in the different areas of transplantation.

uniform than that of the local fish. Among the former (Figure 35) the plaice from the Smaalandsfarvand, the water NW. of Seeland and the Great Belt have been growing rapidly and uniformly, those liberated in the Sound have been growing well during the first months, but later on they have not kept up with the growth rate of the rest; the opposite state of things was found in the plaice put out in the Little Belt and round Ærø. The growth curves of the local planted fish the local plaice liberated in the Sound have been growing well, which would seem to indicate that the extreme conditions of the Sound, more particularly the low salinity, have been a greater hindrance to the transplanted than to the local fish.

Apart from this there have been no great differences in the growth of fish liberated in the different areas. This fact would seem to suggest that on the whole

Table 19. Average length increment per month of the years 1928—1933 in marked North Sea plaice transplanted to the areas I—VIII.

Area	I		II		III		IV		V		VI		VII		VIII	
Recaptured number of months after liberation	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.
0 Apr.....	65	0.3	27	0.2	20	0.4	9	0.3	66	0.2	13	0.5	30	0.2	67	0.1
1 May....	146	0.5	97	0.5	58	0.4	40	0.6	292	0.4	18	1.0	59	0.8	112	0.3
2 Jun.....	73	1.7	61	2.2	40	1.8	35	3.2	67	1.1	10	2.6	63	2.9	46	1.4
3 Jul.	60	3.5	69	4.1	30	3.5	63	4.5	56	2.6	20	4.7	68	4.9	24	1.7
4 Aug. ...	75	5.2	35	5.0	23	5.0	57	6.5	25	6.1	13	6.2	15	5.6	8	6.0
5 Sept....	37	7.7	35	6.1	9	7.2	17	7.8	18	7.1	10	8.6	11	7.2	3	9.0
6 Oct.....	26	8.9	28	8.0	4	9.8	9	9.3	8	8.9	3	8.2	3	8.7	3	9.0
7 Nov. ...	22	11.3	10	9.6	2	9.3	10	10.5	4	11.8	7	12.7	1	9.5	5	10.4
8 Dec.....	18	10.6	18	11.7	11	11.0	12	11.8	15	11.7	17	11.7	3	11.8	3	11.3
9 Jan.....	50	11.6	36	11.7	23	11.8	18	11.3	14	12.6	20	11.9	..	..	3	10.3
10 Feb.....	22	11.4	15	11.8	11	12.5	8	12.2	14	12.4	8	14.3	1	13.0	6	10.4
11 Mar. ...	18	11.3	12	12.5	4	15.0	3	10.7	8	11.9	6	11.8	..	..	1	9.0
12 Apr.....	10	10.9	8	12.4	3	13.0	3	10.8	9	10.2	1	13.0	1	14.0	1	8.5
13 May....	8	13.1	8	12.2	5	14.2	4	12.1	11	11.9	..	..	3	13.8	..	..
14 Jun.....	5	13.6	2	13.0	3	15.7	5	14.9	3	8.7	4	13.1	..	..	..	..
15 Jul.	10	13.9	2	14.8	..	..	1	13.5	6	18.6	2	12.8	..	..	1	19.0
16 Aug. ...	..	..	2	15.8	1	12.0	..	..	3	17.2	1	14.0	..	..	..	..
17 Sept....	2	13.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..
18 Oct.....	1	16.0	1	14.5	..	..	..	..	..	..	..	..	..	..	..	..
19 Nov. ...	..	..	3	13.2	1	16.0	..	..	..	..	2	14.8	..	..	..	..
20 Dec.....	5	18.3	1	14.5	1	18.0	1	18.5	..	..	..	..	..	..	..	..
21 Jan.....	1	14.0	1	12.5	..	..	3	18.7	..	..	1	16.0	..	..	..	..
22 Feb.....	1	17.0	1	22.0	1	16.0	..	..	1	20.0	..	..	..	..	..	..
Total...	655		472		250		298		620		156		258		283	

Table 20. Average length increment per month of the years 1929 and 1931—33 in marked local plaice liberated in the areas I—VIII.

Area	I		II		III		IV		V		VI		VII		VIII	
Recaptured number of months after liberation	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.	No. of ind.	Aver. growth incr. in cm.
0 Apr.....	69	0.3	17	0.2	13	0.2	9	0.3	176	0.3	2	0.0	39	0.3	52	0.4
1 May....	155	0.7	71	0.9	38	0.5	49	0.4	228	0.5	7	0.1	58	0.5	89	0.5
2 Jun.....	84	1.0	89	1.9	53	1.6	46	1.3	123	1.1	3	0.7	43	2.4	34	0.9
3 Jul.	45	2.4	79	3.0	32	2.8	46	3.0	64	2.7	12	1.2	30	3.9	26	2.5
4 Aug. ...	39	3.5	37	4.0	24	4.4	37	4.6	41	4.2	10	4.7	6	5.3	8	4.8
5 Sept....	39	5.0	30	5.5	8	4.7	12	7.0	8	5.7	6	6.8	1	7.0	5	6.7
6 Oct.....	16	5.6	10	6.8	9	5.3	11	8.0	9	7.0	3	7.0	1	7.5	2	9.0
7 Nov. ...	14	6.5	6	7.7	12	9.1	7	8.6	8	9.3	3	9.3	1	6.5	6	8.4
8 Dec.....	17	6.0	6	8.2	14	7.5	2	7.8	4	7.0	3	8.5	2	12.0	2	7.3
9 Jan.....	32	7.3	7	6.8	16	8.7	6	8.1	11	8.8	6	8.7	..	..	3	9.7
10 Feb.....	20	7.2	10	7.6	15	7.9	5	9.0	15	8.9	4	8.4	1	6.5	1	9.0
11 Mar. ...	13	7.7	3	7.5	6	8.1	3	10.3	5	9.4	2	9.3	..	..	3	7.7
12 Apr.....	12	7.9	3	11.3	2	10.0	1	1.0	5	10.1	2	8.5	..	..	2	8.8
13 May....	15	8.4	3	11.3	2	9.8	3	13.0	8	8.9	2	8.0	2	10.3	2	11.0
14 Jun.....	11	8.5	4	7.4	5	11.1	5	10.8	4	9.9	..	..	..	..	..	..
15 Jul.	10	9.6	1	12.5	1	11.5	2	12.8	5	12.1	..	..	1	13.5	3	10.7
16 Aug. ...	4	10.3	1	11.0	1	16.0	1	13.0	1	14.0	1	6.0	..	..	..	..
17 Sept....	2	10.3	..	..	1	10.0	..	..	1	16.5	..	..	..	..	..	..
18 Oct.....	2	10.0	..	..	..	..	..	..	..	..	..	..	..	..	..	..
19 Nov. ...	2	12.8	..	..	2	14.3	..	..	..	..	..	..	..	..	..	..
20 Dec.....	2	16.3	..	..	2	12.5	..	..	..	..	..	..	..	..	..	..
21 Jan.....	1	9.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22 Feb.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total...	604		377		256		245		716		66		185		238	

conditions of nourishment and other vital factors are the same in the different areas and have turned out to be satisfactory; as a matter of fact plaice have been liberated only in localities in which special investigations with the bottom sampler had previously established good and ample nourishment to be present.

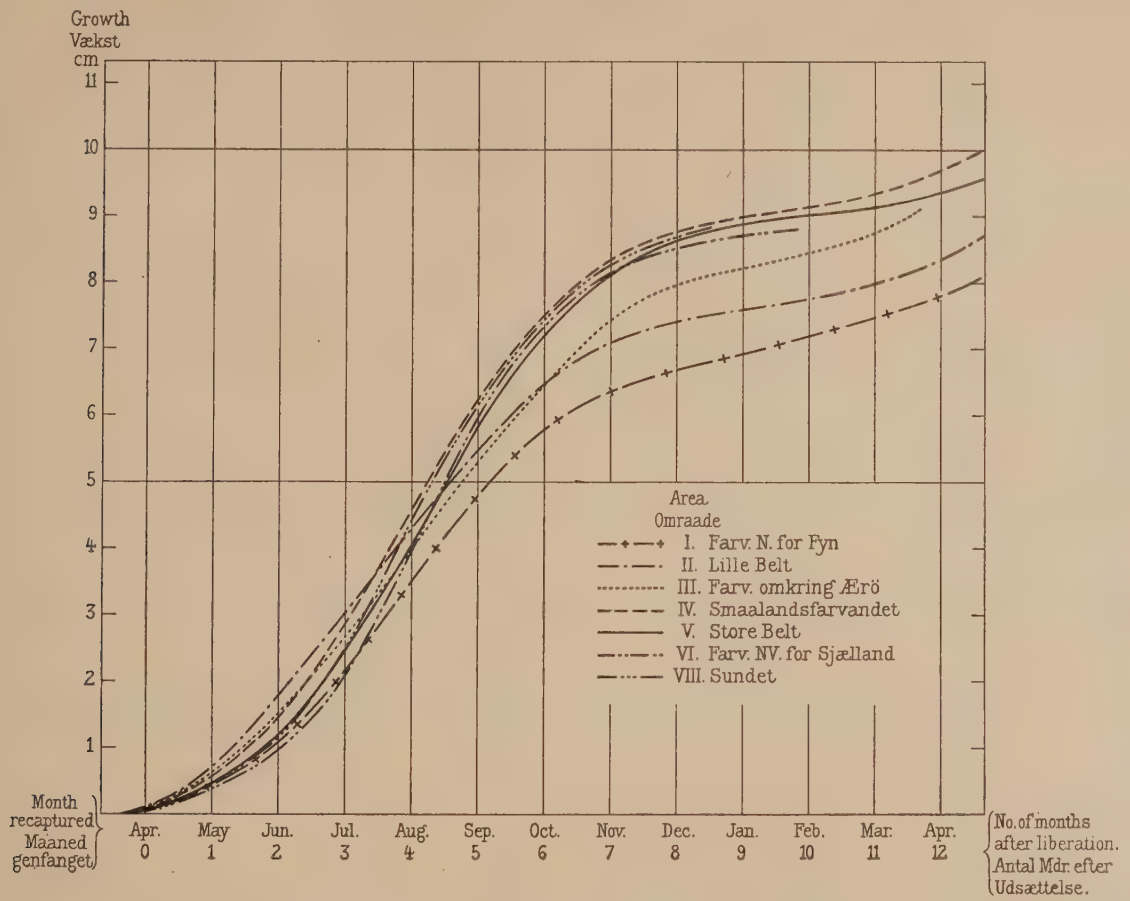


Figure 36. Growth curves of the marked local Belt Sea plaice liberated in the different areas of transplantation.

III. The profitableness of the transplantations.

The earlier works of the present author (**1932** and **1933**) contain calculations on the yield of the transplantations. The results were reached partly in using the percentage recaptures of marked fish in 1931, partly in carrying out race analyses of the captures of fishermen, and it was found that the yields might be estimated at an annual amount of between 120 000 and 150 000 Kr.

However, the material in hand now enables us to carry out preciser and more extensive calculations of this kind. In the following the two methods of calculation will be dealt with separately.

A. The profitableness of the transplantations as calculated by the percentage recaptures of marked fish.

The calculations of the previous papers (H. Blegvad, **1932**, p. 92 and **1933**, Figure 6, p. 177) only include one year, but it is now possible to use the average values of each separate month throughout the period of transplantation, from 1928 till 1933, which have been put down in the lower part of Table 10.

A drawback about the earlier methods of cal-

culation was the difficulty in calculating the value of the plaice recaptured during the first months after their liberation. At this time most of the fish transplanted are still undersized individuals, that is to say less than 25.7 cm. long, and may not be landed, but must be liberated at once and, as far as possible, in a state fit to survive. So it is only the marked individuals of the plaice transplanted that are landed as undersized fish; the individuals not marked are put out again in order that they may increase in size. For the purpose of calculating the value of the latter the following procedure was applied.

It appears from Table 2 that on their liberation in April the average size of the plaice transplanted was 21.23 cm. + 0.5 cm. = 21.73 cm. (s. footnote on p.16). According to the growth curves of Figure 32 the average size had reached the minimum size-limit in July of the same year. We shall now calculate how large the percentages of recapture from the month of July upwards would have been if the marked plaice caught in the months of April to June had been re-liberated in an unimpaired condition. Table 10 informs us that an average of 15.47 % of the marked fish transplanted had been caught in the months of April to June or that 1 547 out of 10 000 individuals had already been captured. If these individuals had been put out again without being killed, the month of July, in which 3.52 % or 352 individuals of the remaining 8 453 plaice were recaptured according to Table 10, would have shown a somewhat higher number of individuals recaptured, viz. $352 \cdot \frac{10\,000}{8\,453}$ = 416 plaice. So the percentage of recapture in the month of July would have risen to 4.16 %. The percentage recaptures of the remaining months were calculated in the same way.

In Table 21 these corrected percentages of recapture are put down together with the average lengths of the plaice in the different months, calculated by the growth curves of Figure 32. Furthermore, the table contains, for each separate

Table 21. The annual value of transplanted fish recaptured, calculated by the percentage recaptures of marked plaice (only fish above the minimum size-limit).

Month	Month No.	Percentage recapture of transpl. plaice unmarked	Average length of plaice recaptured	Corresponding weight in g.	Calculated weight in Kg. of transpl. plaice recaptured	Price to the fishermen, given in Øre per Kg.	Calculated value in Kr. of transpl. plaice recaptured
A.	0	..	21.8	..	..	..	..
M.	1	..	22.6	..	..	..	..
J.	2	..	23.9	..	..	..	..
J.	3	4.16	25.5	160	7 987	55	4 393
Au.	4	2.91	27.2	210	7 333	60	4 400
S.	5	1.62	28.9	258	4 980	70	3 486
O.	6	0.93	30.7	315	3 515	90	3 164
N.	7	0.70	32.3	366	3 074	120	3 689
D.	8	1.09	33.4	403	5 271	130	6 852
J.	9	1.86	33.7	414	9 240	120	11 088
F.	10	0.92	33.7	414	4 571	120	5 485
M.	11	0.67	33.7	414	3 329	120	3 995
A.	12	0.40	33.7	414	1 987	120	2 384
M.	13	0.43	34.0	423	2 183	150	3 274
J.	14	0.22	35.0	461	1 217	175	2 130
J.	15	0.27	36.2	505	1 636	180	2 945
Au.	16	0.12	37.3	549	791	180	1 424
S.	17	0.01	38.1	582	70	190	133
O.	18	0.04	38.6	604	290	160	464
N.	19	0.07	38.8	613	515	160	824
D.	20	0.09	38.8	613	662	150	993
J.	21	0.12	38.8	613	883	140	1 236
F.	22	0.06	39.0	622	448	160	717
M.	23	0.02	39.4	638	153	160	245
	24—33	0.07	c. 40.6	c. 700	588	160	941
Total.		16.78 %			60 723		64 262

month, such weights in grammes as have been calculated to correspond to the various lengths, for which calculations was used the information (given in Table 22) on the weight of 993 marked plaice transplanted and recaptured.

Basing on the annual mean number of plaice transplanted in 1928—29 and 1931—33 (1.2 million specimens) also the total weight of the transplanted plaice recaptured in each month was calculated by means of the percentages of recapture and individual weights given in the previous columns. The next column states the average price obtained by the fishermen throughout the years of transplantation per Kg. of plaice of the said weight classes and during the months in question. These items of information were most kindly put at my disposal by Mr. Axel Nielsen, Fishmerchant of Fredericia. The last column shows the value of the monthly weight quantities of transplanted plaice recaptured, calculated on the basis of the figures of the two previous columns.

It appears from Table 21 that in using this method of calculation, in which no regard is paid to the quantities of transplanted fish actually caught by the fishermen, we get a yield of more than 64 000 Kr., an amount exceeding the real costs of the transplantations (about 44 000 Kr.) by more than 20 000 Kr. So we see that even by an annual percentage of recapture of 16.78 (see Table 21) these transplantations have left a margin of 46 %. But there is no doubt that the actual percentage of recapture has been much higher. Firstly, the number of fish forwarded to the Station is far from the actual quantity of marked fish recaptured, secondly, some plaice will lose their labels in the course of time. So the above figure cannot be considered representative of the profits of the fishermen or the yield of the transplantations, and the calculation was carried out only for the purpose of examining whether the transplantations would turn to account if the fishermen's recaptures of unmarked fish correspond to the percentage of marked fish delivered to the Biological Station, all fish sent in during the first three months being supposed to have been re-liberated.

However, the actual profits of the fishermen by the transplantations may be estimated by directly examining how great a part of their catches consists of fish transplanted. This examination is dealt with in Chapter B.

Table 22. Individual average weight of recaught, marked North Sea plaice transplanted during the years 1931—33.

No. of ind. examined	Total length in cm.	Individual aver. weight in g.	Smoothed indiv. aver. weighting.
47	25.75	155.7	165
80	26.25	183.9	180
38	26.75	198.8	195
60	27.25	217.9	210
36	27.75	216.3	225
65	28.25	237.2	240
32	28.75	260.4	255
48	29.25	262.6	270
30	29.75	284.4	285
39	30.25	313.7	300
22	30.75	323.6	316
51	31.25	328.0	332
38	31.75	353.0	348
40	32.25	363.6	364
18	32.75	379.7	381
27	33.25	389.6	398
17	33.75	387.9	415
46	34.25	428.9	433
26	34.75	453.4	441
48	35.25	474.1	469
16	35.75	490.3	488
39	36.25	513.6	507
22	36.75	545.4	527
28	37.25	537.4	547
13	37.75	568.1	568
20	38.25	578.8	589
5	38.75	558.0	611
11	39.25	638.0	633
0	39.75	..	656
5	40.25	716.0	680
1	40.75	765.0	706
5	41.25	740.0	734
4	41.75	745.0	762
5	42.25	827.0	790
3	42.75	940.0	820
2	43.25	920.0	..
0	43.75	..	..
1	44.25	750.0	..
3	44.75	1180.0	..
0	45.25	..	..
1	45.75	1100.0	..
1	46.25	1150.0	..
993			

B. The yield of the transplantations as calculated by analyses of the catches of fishermen.

It has already been hinted at that the fish transplanted belong to a special race, the "North Sea race", which differs from the "Baltic race", to which the local Belt Sea plaice belong, in having,

Table 23. Weight quantities of transplanted North Sea plaice in samples taken from

	Jul.				Aug.				Sept.				Oct.				Nov.		
	Year	N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.
I	1929	14.00	21.25	73	1932	3.02	13.08	50	1931	2.75	11.56	44	..	..	..	..	..	..	..
	—	23.00	45.00	152	—	4.48	11.78	52	—	5.15	12.74	35	1931	2.72	10.04	34	..	..	..
	—	9.25	25.00	83	—	8.46	14.44	52	..	..	..	..	—	5.05	12.93	49	..	..	..
	..	..	..	..	—	8.65	12.75	47	..	..	..	..	1932	5.49	15.27	52	..	..	..
	..	..	..	..	—	1.24	8.92	39	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	—	1.11	9.18	39	..	..	..	..	..	..	..	..	..	..	..
II	..	..	..	..	1932	7.39	9.86	37	1931	8.46	14.61	47	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	—	7.63	14.11	51	..	..	..	..	1933	5.36	17.15
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
III	..	..	..	..	1932	3.83	19.74	42	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	—	1.35	7.77	24	1931	0.92	9.69	23	1931	3.43	20.44	46	1931	4.94	19.68
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
IV	..	..	..	..	..	..	..	..	1932	1.16	9.98	43	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	—	1.89	8.11	29	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	1933	0.88	7.28	33	..	..	..	..	..	..	..
V	..	..	..	..	..	..	..	..	1931	4.40	11.37	55	..	..	..	..	1931	6.05	13.65
	..	..	..	..	1932	6.46	9.05	40	1932	3.68	4.20	20	..	..	..	..	1933	0	9.46
	..	..	..	..	..	..	..	..	—	10.46	12.83	54	..	..	..	..	—	3.93	19.18
VI	..	..	..	..	..	..	..	..	1932	0.69	12.54	50	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	—	3.49	12.74	51	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	1933	0	13.00	64	..	..	..	..	..	..	..
Total	..	46.25	91.25	308	..	45.99	116.57	422	..	51.56	154.76	599	..	16.69	58.68	181	..	20.28	79.12
N.% I—VI		50.7 %				39.0 %				33.5 %				28.4 %				25.6 %	

N.Kg. = weight of North Sea fish in Kg. T.Kg. = weight of total sample in Kg. T.N. = total number of plaice examin

among other things, a higher number of fin rays (generally about 54 anal fin rays as against 48—50 rays of the Baltic race) and a more slender shape. The latter fact appears from the subjoined Figures 37 and 38, showing a local Belt Sea plaice and a transplanted North Sea plaice of fairly the same size.

H. Blegvad phot.

Figure 37. Typical local Belt Sea plaice. 1/3 natural size.

The typical shape of the transplanted North Sea plaice, which was at once noticed by the fishermen of the Danish Belt Sea waters, enabled the fishermen to estimate the numbers of transplanted fish caught in their gears. We shall see later that these quantities were not at all insignificant. This fact has contributed essentially to the popularity of the transplantations among fishermen.

Besides the shape and the number of fin rays there is still an important factor left that allows us to establish the quantity of transplanted fish in the catches of the fishermen, viz. the otoliths, by which, as is well-known, it is possible to read the age and growth of the fish.

ches of fishermen inside the areas I—VI during the period from July to April 1929—33.

Dec.			Jan.				Feb.				Mar.				Apr.				Jul.—April		
ar N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.	T.N.	Year	N.Kg.	T.Kg.	T.N.	N.Kg.	T.Kg.	T.N.
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	..	..	..	..	1932	1.86	8.55	32	..	..	..	..	..	..	..	..			
..	..	..	1930	7.10	34.60	94	—	0.38	17.65	48	1933	2.89	13.04	45	..	..	..	..			
..	..	..	1931	6.40	20.13	50	—	2.05	13.99	46	..	..	..	..	..	..	..	..	118.84	347.42	1178
..	..	..	..	..	..	..	—	3.79	15.52	62	..	..	..	..	..	..	..	..			
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	1930	12.76	40.82	79	..	..	..	..	..	..	..	..	..	..	..	..			
3 24.66	34.20	45	1932	12.22	22.94	50	..	..	..	..	..	..	..	..	..	..	..	..	95.37	178.43	398
..	..	..	1933	16.89	24.74	48	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	1932	1.04	16.76	49	..	..	..	..	..	..	..	..	..	..	..	..			
1 1.72	42.80	100	—	1.71	13.43	49	..	..	..	..	..	..	..	..	..	..	..	..	21.05	171.60	450
..	..	..	1933	2.11	21.29	63	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	..	..	..	..	1932	0.17	6.09	23	..	..	..	..	..	..	..	..	4.10	31.46	128
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	1930	9.84	47.00	99	..	..	..	..	..	..	..	..	..	..	..	..			
3 2.25	24.01	48	1933	4.21	24.59	53	..	..	..	..	1932	1.47	16.50	39	1930	0.34	16.40	61	53.09	208.24	596
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..			
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4.18	38.28	165
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..			
28.63	101.01	193	..	74.28	266.30	634	..	8.25	61.80	211	..	4.36	29.54	84	..	0.34	16.40	61	296.63	975.43	2915
28.3 %				27.8 %				13.3 %				14.5 %				2.1 %				26.3 %	

= weight per cent. of North Sea fish.

Firstly, it appears from Tables 3 to 6 that nearly all the fish transplanted are more than 3 to 6 years old, whereas the local Belt Sea fish of the corresponding size are only 1 to 3 years old; on the whole Belt Sea plaice of more than 4 years are rarely met with, most of them being caught before they grow as old as that. Secondly, it is distinctly to be seen by the otoliths of the plaice transplanted that their growth has been slow during their first, but rapid during their last year, or years, of life. For in the otoliths of the local Belt Sea fish the growth zones are uniform and rather broad, but in the otoliths of the transplanted North Sea fish we find — what was originally established in the marked fish — an inner series of very narrow growth zones, corresponding to the number of years spent in the Horns Reef area under poor conditions of nourishment, but at the outer edge they have one or more very broad growth zones, which testify

H. Blegvad phot.

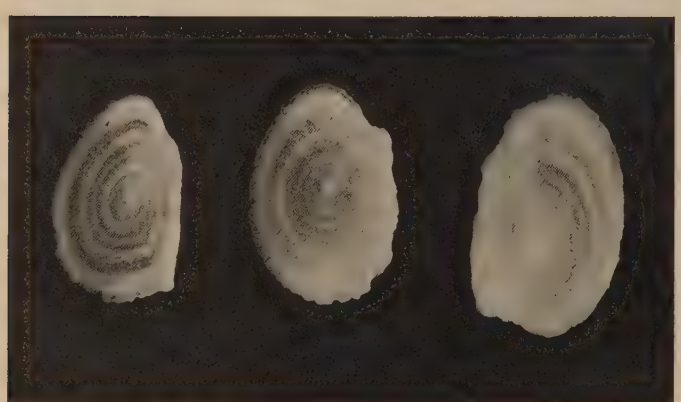
Figure 38. Typical North Sea plaice transplanted from the Horns Reef area. 1/3 natural size.

H. Blegvad phot.

Figure 39. Otoliths of plaice caught by fisherman 2 nautical miles south of Endelave (Area I) on October 17th, 1933. Upper series taken from 4 local Belt Sea fish, respectively 25, 26, 28 and 31 cm. in length and showing an age of $1^1/_2$ and $2^1/_2$ years. Lower series taken from 1 Belt Sea fish, 31 cm. long, $3^1/_2$ years old, and from 2 North Sea fish transplanted in April 1933, respectively 33 and 42.5 cm. long and $5^1/_2$ and $6^1/_2$ years old. Note the broad, uniform growth zones in the otoliths of the Belt Sea fish as contrasted with the narrow inner zones and the broad outer zones in the otoliths of the North Sea fish. About 4 times natural size.

H. Blegvad phot.

Figure 40. Otoliths of plaice caught by fisherman west of Samsø (Area I) on October 17th, 1933. Upper series of otoliths taken from 3 local Belt Sea fish, respectively 21, 26 and 32 cm. long and $1^1/_2$, $2^1/_2$ and $3^1/_2$ years old, lower series from 3 transplanted North Sea fish, respectively 34, 39.5 and 35 cm. in length, all showing an age of $5^1/_2$ years. The two very broad white zones at the outer edge of the central otolith show that this plaice has spent two growth periods in the Belt Sea, being transplanted in 1932. The other two otoliths have but one broad white zone at the edge: these fish were transplanted in the spring of 1933. About 4 times natural size.



H. Blegvad phot.

Figure 41. Otoliths of transplanted North Sea plaice caught by fisherman at Aabenraa (Area II) on December 4th, 1933. The two specimens to the left indicate an age of $4^2/_3$ years and prove the transplantation of the two plaice in question to have taken place in the spring of 1933 (1 growth period in the Belt Sea). The otolith to the right shows that this plaice had an age of $5^2/_3$ years and was transplanted to the Belt Sea in the spring of 1932 (2 growth periods in the Belt Sea). About 4 times natural size.

to the ample nourishment and rapid growth of the Belt Sea. Figures 39—43 are illustratory of these facts. In plaice of more than 2 or 3 years the normal growth zones will be narrowing towards the edge, the growth rate decreasing with the increasing age of the fish, but in the fish transplanted we find the very characteristic fact that the growth zones broaden towards the edge.

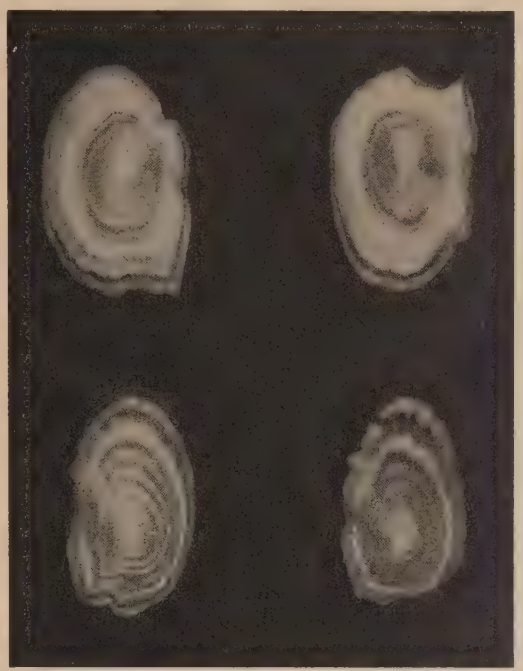
By means of these three factors: shape, number of fin rays, and otoliths, analyses of the catches of fishermen have been carried out throughout the areas of transplantation during the period from 1929 till 1933. In Table 23 the results of these analyses inside the areas I—VI have been grouped by the month. Besides the time of the investigation we find here the weight of the North Sea fish transplanted, the total weight in Kg. of the whole catch sample and the total number of plaice examined. In the lower part of the table monthly statements give the total weight of the fish transplanted and of the whole catch, and finally the weight percentage of North Sea fish.

It will be noted that the weight percentage falls comparatively rapidly from July till November, but

H. Blegvad phot.

Figure 42. Otoliths of transplanted North Sea plaice caught at the same time and place as the fish mentioned in Figure 41. The two upper otoliths and the left one below indicate an age of $5^2/_3$ years and a stay in the Belt Sea lasting two summers. The fourth otolith originates from a fish that is $6^2/_3$ years old and has spent 1 summer in the Belt Sea. About 4 times natural size.

is constant during the months of December and January — probably because at this time the fishery works the mature stock of the deeps, which is constantly supplemented by transplanted fish that have



H. Blegvad phot.

Figure 43. Otoliths of transplanted North Sea plaice caught by fisherman at Læsø on January 15th, 1935. The two upper otoliths were taken from the same plaice, which was 49 cm. long, had a weight of 1350 g., 54 anal fin rays, was nearly 8 years old, and had been transplanted to the Belt Sea in the spring of 1932 (3 summers spent in the Belt Sea). The left otolith below shows an age of nearly 8 years; the transplantation took place in 1933 (2 summers spent in the Belt Sea). This plaice was 40 cm. long, weighed 730 g. and had 55 anal fin rays. The right otolith below originates from a nearly 6-years-old plaice, which had been transplanted in 1933 (2 summers spent in the Belt Sea). Its length was 38 cm., its weight 640 g., and it had 55 anal fin rays. All these plaice were mature females. About 4 times natural size.

arrived at the stage of maturity. But during the months of February, March and April there is another very rapid fall of the weight percentage of the fish transplanted.

If we use the weight percentages of the different months in connexion with the fishery statistics for the purpose of calculating the average weight amounts of transplanted plaice occurring in the fishermen's catches in the Belt Sea waters during the years of transplantation (1929 and 1931—1933), we get the following result (Table 24).

Table 24. Statistics showing the monthly weight yield in Kg. of the plaice fishery inside the areas I—VI in 1929 and 1931—33, and the annual average weight yield in Kg. of the plaice transplanted in these years.

	1929	1931	1932	1933	Annual average	Percentage of North Sea fish	Plaice transplanted
	Kg.	Kg.	Kg.	Kg.	Kg.		Kg.
January	58 491	159 867	85 018	110 340	103 429	27.8	28 753
February	2 390	104 506	72 803	46 275	56 494	13.3	7 514
March	18 682	80 670	46 399	38 816	46 142	14.5	6 691
April	61 443	39 132	41 779	30 028	43 096	2.1	905
May	48 574	54 937	51 932	42 305	49 437	..	..
June	58 373	61 497	97 918	58 732	69 130	..	..
July	71 969	79 985	95 153	66 402	78 377	50.7	39 737
August	99 428	93 469	103 093	75 180	92 793	39.0	36.189
September	60 292	54 535	55 755	52 742	55 831	33.5	18 703
October	52 696	50 258	37 921	41 904	45 665	28.4	12 969
November	54 092	66 095	58 774	58 689	59 413	25.6	15 210
December	39 463	76 620	99 491	80 604	74 045	28.3	20 955
Per year...	625 893	921 571	846 036	702 017	773 879	..	187 626

187 626 Kg. at 0,90 Kr. = 168 863 Kr.

Instead of the average calculation per year formerly used this table contains sums worked up per month; the reason of this is that both the found percentages of fish transplanted and the weight yields of the catches of the fishermen are subject to such variations from month to month, that an average calculation per year would in both cases be less reliable. It will be seen that in the monthly yields of the fishery there are two summits, one in July—August and another in December—February; in the winter of 1929, only, the fishery was far below mean on account of the Belt Sea being covered with ice during the severe winter season of that year.

The right-hand column of Table 24, which is based on the figures of the two previous columns, represents the average weight yield in Kg. of the transplantations of the years 1929 and 1931—33. In total we get an annual weight yield of 187 626 Kg. At an average price of 0.90 Kr. a Kg., which is a low estimate (the fishery statistics reckoning about 0.95 Kr.) this weight amount gives the fishermen an annual profit of 168 863 Kr. It is interesting to note that this figure is not very far from the amount of 157 500 Kr. formerly calculated by the author (**1932**, p. 93). Here the average percentage of North Sea fish in the catches of the fishermen was estimated at 25 for the whole year of transplantation 1931/32. That this estimate was not totally beside the mark appears from the fact that the figures arrived at in the above calculation yield a percentage of 24.2 for the whole of the year.

It should be remembered that the areas VII and VIII (the Isefjord and the Sound) were not included in the above calculations; in these localities the investigations were but few (2 in the Isefjord on 17-X-1931 and 26-IX-1933 showing 35 and 0 % of North Sea fish, respectively, and 3 in the Sound on 25-XI-1931, 5-III-1932 and 3-X-1932 showing 19, 11 and 21 % of North Sea fish, respectively), and the yield of the plaice fishery is small in comparison with that of the other areas of transplantation. Accordingly, the amount mentioned above is the minimum profits of the transplantations as a whole.

The costs of the transplantations, which were defrayed by the Government, amounted to a sum of 60 000 Kr. in 1928, 1929 and 1931, and 50 000 Kr. in 1932 and 1933, including the costs of the scientific survey. According to the above calculations the annual minimum profits of the fishermen was about 168 800 Kr. So the transplantations must be considered to have been very profitable indeed. It will perhaps be wondered at that the liberation of the comparatively small number of little more than one million plaice should influence the yield of the fishery to such a degree, but when converting the total weight of plaice into number of individuals caught in the Belt Sea during 1928—1933, we arrive at some 3 millions individuals a year, and thus the additional million is of some consequence. As a matter of curiosity may be men-

tioned that if all the North Sea plaice transplanted in 1933 were supposed to be ranged on one line — the transplantations of this year including 1 114 900 specimens with an average length of 22 cm. — this line would be 245 km. long and reach from Esbjerg to Taastrup between Roskilde and Copenhagen!

IV. Are small or large plaice, young or old plaice to be preferred as objects of transplantation?

It has previously been mentioned that the plaice transplanted in the different years did not show the same average length or age. It appears from Table 2 that the average length of the fish transplanted was smallest in 1928 when more than three fourths of the plaice, the Thyborøn fish, averaged 17.6 cm. in length. Next come the years 1932 with 20.5 cm., 1931 with 21.6, 1929 with 21.9 and finally 1933 with 22.0 cm. The year 1930 was not considered, the material being too small. The corresponding distribution of the average age of the plaice was: in 1928 3 years, in 1929 4 years, in 1931 3 and 4 years, in 1932 4 years and in 1933 5 years (Table 6).

If, then, we wish to examine whether it is more profitable to transplant small than large plaice, it will be natural to begin with looking into the growth of the different years. Figure 33 shows that the poorest growth was decidedly met with in 1928 when the plaice were smallest. The growth curves of the other years are so much like each other, that it is difficult to give prominence to a single year; however, the growth seems to have been most rapid in 1929 when the plaice transplanted were rather large. On the other hand the plaice transplanted were largest in 1933, but in this year their growth was not very rapid.

The percentage recaptures of the different years are stated in Table 25 which also includes a survey of the recaptures from respectively the fourth and third month after the liberation because, as demonstrated on pp. 29 and 74, these figures are a more reliable expression of the importance of the transplantations to the fisheries than the total percentages of recapture.

Table 25.

Recaptures in per cent. of transplanted, marked fish.

Year	From fourth month inclusive	From third month inclusive	Total
1928	5.4	7.7	21.0
1929	10.4	14.0	30.6
1931	16.9	21.5	39.5
1932	10.8	15.5	32.1
1933	7.9	10.9	24.0

A look at the survey will show that all three categories of percentage recaptures tell the same thing: the recaptures of marked fish were smallest in 1928, considerably larger in 1933, still larger in 1932 and 1929, the results of these two years being fairly the same, and largest in 1931.

A comparison of what has been stated above on the growth and the percentage recaptures in the various years of transplantation will show that in both respects the year 1928 yielded the poorest result. The succession of the following years is clear only as far as the percentages of recapture are concerned; 1933, in which year the largest and oldest fish were transplanted, seem to have yielded a rather poor result as regards the growth as well as the percentage recaptures. In 1931 the fish to be transplanted were comparatively young but rather large; this year returned the highest percentage of recapture, and the growth was rapid, too.

As mentioned on p. 68 it is just possible that want of experience in 1928, the first year of transplantation, was one of the causes of the poorer growth of this year. On the other hand this is hardly the only cause of the growth and percentage recaptures of this year being much inferior to those of the others. Well-smack skippers know by experience that small plaice are far less resistant than large ones during a long transport. Speaking generally we may no doubt say that it is unprofitable to transplant plaice of the small average size of the year 1928 (17.6 cm.); an average length of about 21 cm. and an age of about 4 years in the fish to be transplanted have turned out to produce the best results.

V. Future transplantations.

After five years of experiments the transplantations were carried on in 1934, and it is to be hoped that they will be carried on annually as long as the present conditions exist. For it is evident that it will always be a profitable measure to remove plaice from an overcrowded locality containing a stock of partially starving and slowly growing individuals to other waters, where the dwarfish growth is succeeded by so rapid a growth, that it exceeds even that of the local stock of fish.

It has formerly been reported by the present author (**1932**, p. 93) that proposals have been made on the part of the fishermen to the effect of contributing to the transplantations in levying a certain tax upon the neighbouring fishermen, for instance in proportion to the mechanic power used in the fishery. But according to paragraph 1 of the Danish Fisheries Act all Danish fishermen are allowed to fish anywhere in Danish waters, and it will be difficult to impose a tax on certain fishermen for the purpose of improving the local stock of fish by means of transplantations as long as other fishermen are allowed to benefit from these measures in fishing in the area of transplantation. As a temporary measure such associations of fishermen as intend to pay some amount of money towards the transplantations may have an extra quantity of plaice transplanted to their respective waters, corresponding to twice the amount yielded by the association.

So the Government will still have to meet the expenses towards the transplantations, but it is a deplorable fact that up to now very little has been done towards the establishment of an adequate protection of the fish transplanted; considering the high percentage recaptures of marked fish during the first period after each transplantation such a protection is most urgent.

As a matter of fact the interest of the fishermen about the transplantations has often manifested itself in the general meetings of their head organisation when the question of establishing some protection of the fish transplanted was discussed. The proposals made have generally been to the effect of forbidding any kind of plaice fishing for a certain period, for instance one month, after the beginning of the transplantations, and it has been planned to establish such a close time after the transplantations in the spring of 1935. But here some difficulty arises: under favourable conditions the transplanting of 1.2 million plaice may be concluded within one week, but when rough weather sets in, it may easily extend over several weeks, so that a great part of the plaice will not benefit from the close time. Consequently the latter ought to be extended to at least two months.

A convention between the Baltic states has already brought about a close time for Baltic plaice during the spawning period in the months of February and March. This convention also includes the areas of transplantation in the western Baltic, and proposals have been made to the effect of extending the close time to the whole transplantation area of the Belt Sea. This would no doubt be a most adequate measure and would mean a much-needed protection of the spawning stock of both transplanted and local fish during the very time when the plaice are of small value and badly paid on account of the spawning. If the transplantations were moreover connected with a raising of the minimum size-limit of plaice inside the areas of transplantation, a measure which was adopted several years ago in the Limfjord, we should no doubt experience a very considerable rise of the profits derived from the transplantations. As it is, however, the chances for a raising of the minimum size-limit are but small although many fishermen of the localities of transplantation are in favour of this measure, for it is maintained by the Ministry of Fisheries that for the reasons of control the minimum size-limit must be the same throughout the Danish waters.

The scientific survey is carried on together with the transplantations, so that we are able to follow the effects of the separate transplantations by means of markings, measurings and age-determinations by the methods described above.

From the transplantation of 1934 a change has been made to the effect of reducing the payment of marked plaice sent in from 2 Kr. apiece to 1 Kr. + the value of the fish and the charge for delivery. Furthermore, if the marked plaice recaptured are undersized, they must be put out again alive, marked plaice being accepted only if they have reached the minimum size-limit. By this plan we shall be able to calculate more accurately the yield

of the transplantations by the number of marked fish recaptured (comp. Chapter III A).

There is no doubt that it would be possible to carry out transplantations on a still larger scale; a removal from the Horns Reef area of an even considerably larger number of plaice for transplanting purposes would mean no disadvantage whatever to the stock of this locality. According to the calculations of Å. J. C. Jensen at least 100 million plaice of the size used for transplantations were living on the Horns Reef in the spring of 1932. If anything, a thinning of the stock must be considered an advantage in bringing about a more rapid growth of the individuals remaining.

Regarding the question whether there are other areas to which plaice could profitably be transplanted, attention should be drawn chiefly to the Dogger Bank, a locality in which earlier investigations have established a very rapid growth and a high percentage recapture of marked plaice transplanted. The distance from the Horns Reef is not so long as to render a transplantation from here to the Dogger Bank an impossibility (see Å. V. Tåning, **1934**). Up to now, however, any attempt of bringing about an international collaboration for the purpose of transplanting plaice to the Dogger Bank has turned out to be unsuccessful. It is to be hoped that future efforts may result in a rational solution of this important problem.

In April 1934 Denmark and Norway collaborated in an experimental transplantation of plaice from the Thyborøn to the Oslo Fjord (Broch, Huitfeldt-Kaas and Ruud, **1934**), and as far as can be seen at present the results of this experiment have turned out to be good. Furthermore, arrangements have been made between Denmark and Sweden for a transplantation of plaice from the North Sea to Swedish waters in 1935. Besides, large-scale transplantations were carried out in Germany in the spring of 1934 (E. Fischer, **1934**). So there is a vivid interest in this matter in our neighbouring countries. On the whole, large-scale transplantations of plaice will in future no doubt come to form part of the efforts of the Northern European countries to forward the fishery and increase its profits.

VI. Summary.

1. During the years 1928—33 a total of little more than half a million Kg. or 6 million plaice have been transplanted from the North Sea (principally the Horns Reef Area) to the Belt Sea (the waters round Funen and Seeland). Figure 2 on p. 14 gives the weight and number of fish transplanted in the different years.

2. Nearly 20 000 plaice transplanted were measured and weighed before their liberation (Table 2, p. 16). In 1928 most of the fish to be transplanted were taken near the Canal of Thyborøn (the Limfjord); these fish were much smaller than those from the Horns Reef.

3. About 6 000 age-determinations were carried out in the fish to be transplanted. Most of the Thyborøn fish were 3 years old, the age of the Horns Reef fish averaging 4 years (Tables 3 & 4, p. 17); among the latter 5-years-old fish predominated in 1930 and 1933 (Tables 5 & 6, p. 18 & 19).

4. More than 12 000 North Sea plaice transplanted were marked in order that their growth, migrations and recaptures might be established. By way of control more than 6 000 local Belt Sea plaice were also marked. Table 7 on p. 24 shows the percentages of recaptures in the different years to range between 21 and 39.5 % as regards transplanted and between 26.9 and 63.6 % as regards local fish. Heavy sea during the transport and long transports in well-smacks do not seem to have influenced the vitality of the fish to be transplanted (p. 26). The total percentages of recapture are no reliable expressions of the results of the transplantations, most of the plaice caught during the first months after their liberation being of no value. Recaptures from the fourth month incl. after the liberation are the best standards of value. Table 10 on p. 28 gives the percentage recaptures of the different months, and according to Table 11 11.4 % of the transplanted and 21.4 % of the local marked plaice had been recaptured within the first two months after the liberation of the fish. In the first months the marked plaice are liable to be caught in nets during their coastward migrations because the labels are entangled in the meshes (p. 28). In the month of January there is a rise of the recaptures (p. 28). On the whole the Smaalandsfarvand appears

to have yielded the largest and the Sound the smallest recaptures (p. 30). Only about 5 % of the recaptures occur during the second year after the liberation (p. 30). Less than 0.5 % of the marked fish transplanted are taken by foreign fishermen (p. 30).

5. The migrations of the marked fish are represented in Figs. 6—28. Most recaptures take place near the localities of liberation; some fish have strayed about inside the area of transplantation, but only 1.9 % of the marked fish transplanted were recaptured outside this area (p. 58). On the whole the migrations of the local fish seem to be less extensive than those of the transplanted individuals (p. 58). Most of the few marked fish transplanted that had carried out long migrations were recaptured at the Skaw, only some few specimens were taken in the Baltic (Figure 30, p. 57). In winter the males will spread over wider areas than the females (p. 60). The seasonal migrations are represented in Figure 31, p. 61. From 17 to 32 % of the female and from 74 to 80 % of the male plaice transplanted will breed inside the area of transplantation (p. 65).

6. The growth of the marked plaice appears from Figs. 32—36. The growth of the transplanted fish has been much more rapid (Average: 12 cm. in the first year, 18 cm. in two years) than that of the local ones (Average: 8 cm. in one year, 13.5 cm. in two years). 1928 exhibits a poorer growth than later years. Plaice liberated in the Smaalandsfarvand, the Great Belt and NW. of Seeland seem to have been growing somewhat quicker than the rest.

7. Calculations on the profitableness of the transplantations have shown that they will turn to account even by a recapture of 16.78 %; this percentage was calculated by the percentage recapture of marked plaice (only fish above the minimum size-limit) in all years (table 21, p. 74). The profits of the fishermen by the transplantations, calculated on the basis of analyses of their catches, may be put at an annual minimum of 168 000 Kr. (Table 24, p. 80).

8. North Sea plaice at an average size of about 21 cm. and an age of 3 or 4 years appear to be the most profitable object of transplantation (p. 81).

9. Still larger quantities of plaice for transplantations may be taken from the Horns Reef area without damage to the stock of that locality. The transplantations should in future be extended to the Dogger Bank (p. 83).

Literature.

Blegvad, H. **1927**. "On the Annual Fluctuations in the Age-composition of the stock of Plaice". Rep. Danish Biol. Stat. XXXIII, 1927.

Blegvad, H. **1932**. "Preliminary Report on the Danish Experimental Transplantations of Plaice from the North Sea to the Belt Sea during the Years 1928—31". Rep. Danish Biol. Stat. XXXVII, 1932.

Blegvad, H. **1933**. "Plaice Transplantations". Journal du Conseil intern. p. l'expl. de la mer. Vol. VIII, No. 2, 1933.

Broch, H., Huitfeldt-Kaas, H., Ruud, Johan T. **1934** "Beretning 1934". Foreningen til Fremme av Fiskeriet i Oslofjorden innenfor Drøbak.

Fischer, E. **1934**. "Ergebnisse der deutschen Verpflanzungsversuche von Nordseeschollen nach der Ostsee". Die deutsche Fischwirtschaft 1. Jahrg., 25. Heft, Oct. 1934.

Jensen, Å. J. C. **1931**. "Investigations of the Plaice Stock in the Southern Horns Reef Area in the Years 1928—30". Medd. fra Komm. f. Danmarks Fiskeri- og Havunders. Bd. IX, Nr. 2, 1931.

Jensen, Å. J. C. **1933**. "Periodic Fluctuations in the Size of Various Stocks of Fish and their Causes". Medd. fra Komm. f. Danmarks Fiskeri- og Havunders. Bd. IX, Nr. 5, 1933.

Kändler, R. **1934**. "Schollenverpflanzung in Dänemark". Der Fischmarkt. Neue Folge. 2. Jahrg. Heft 6. Juni 1934.

Molander, A. R. **1934**. "Om rödspottsbeståndets yngsta årsklasser i södra Östersjön". Ny svensk Fiskeritidsskrift. No. 23, Dec. 1934.

Tåning, Å. Vedel. **1934**. "Omplantning og Mærkning af Rødspætter paa Doggerbank". Dansk Fiskeritidende, Nr. 14, April 1934.

XXI. *C. G. Joh. Petersen:* Valuation of the Sea. II. The Animal Communities of the Sea Bottom and their importance for marine Zoogeography. With 6 Plates, 3 Charts and an Appendix. 110 pp. 1913.

XXII. I. *P. Boysen Jensen:* Studies concerning the organic matter of the Sea Bottom. II. *H. Blegvad:* Food and Conditions of Nourishment among the Communities of invertebrate animals found on or in the sea bottom in Danish waters. III. *C. G. Joh. Petersen:* The Work of the Biological Station from 1889—1914. With Illustrations and Tables. 88 pp. IV. *The same:* Appendix to Report XXI. With 2 Charts. 7 pp. On the distribution of the Animal Communities on the Sea Bottom. 1914.

XXIII. *C. G. Joh. Petersen:* On the Animal Communities of the Sea Bottom in the Skagerak, the Christiania Fjord and the Danish waters. With one Chart and four Tables. 29 pp. 1915.

XXIV. I. *C. G. Joh. Petersen:* On the Development of our Common Gobies (*Gobius*) from the Egg to the Adult Stages etc. With 1 Plate and 3 Figures in Text. II. *H. Blegvad:* On the Food of Fish in the Danish Waters within The Skaw. 72 pp. 1916.

XXV. *C. G. Joh. Petersen:* The Sea Bottom and its production of Fish-Food. A survey of the work done in connection with valuation of the Danish waters from 1883—1917. With 12 Plates and 1 Chart. 82 pp. 1918.

XXVI. I. *P. Boysen Jensen:* Valuation of the Limfjord. Studies on the Fish-Food in the Limfjord 1909—1917, its Quantity, Variation and Annual Production. With 7 Plates and 1 Chart. II. *C. G. Joh. Petersen:* Our Gobies *(Gobiidæ).* From the Egg to the Adult Stages. With 3 Plates. 65 pp. 1919.

XXVII. *C. G. Joh. Petersen:* On the stock of Plaice in relation to the intensive fishing of the present times in the Beltsea and other waters. With 2 Plates. 21 pp. 1920.

XXVIII. *H. Blegvad:* On the Biology of some Danish Gammarids and Mysids. *(Gammarus locusta, Mysis flexuosa, Mysis neglecta, Mysis inermis.)* With 5 Tables. 102 pp. 1922.

XXIX. *C. G. Joh. Petersen:* On the Stock of Plaice and the Plaice Fisheries in different Waters. With 2 Charts and 1 Appendix. 42 pp. 1922.

XXX. *R. Spärck:* Studies on the Biology of the Oyster *(Ostrea edulis)* in the Limfjord, with special Reference to the Influence of Temperature on the Sex Change. 80 pp. 1925.

XXXI. I. *C. G. Joh. Petersen:* The Influence of Fishing upon the Stock of Plaice in the Baltic during recent Years. — II. *R. Spärck:* Investigations on the Size of the Stock of Oysters in the Limfjord 1924. — III. *C. G. Joh. Petersen:* Report to the Ministry of Agriculture concerning increased Motor-Fishing in the Limfjord. — IV. *H. Blegvad:* Continued Studies on the Quantity of Fish-Food in the Sea Bottom. — V. *R. Spärck:* A Comparison between the Danish Oyster-Beds and those in Holland and the South-West of France. 63 pp. 1925.

XXXII. *H. Blegvad:* On the Renewal of the Stock of Plaice in the Baltic proper. 37 pp. 1927.

XXXIII. I. *A. C. Johansen:* On the Fluctuations in the Quantity of Young Fry among Plaice and certain other species of fish, and causes of the same. With 7 figures and 1 table. — II. *A. C. Johansen:* On a Spawning Place for winter spawning Herring in the northern part of the Belt Sea. With 2 figures. — III. *H. Blegvad:* On the Annual Fluctuations in the Age-composition of the stock of Plaice. With 2 figures. — IV. *R. Spärck:* Studies on the Biology of the Oyster *(Ostrea edulis).* II—IV. 65 pp. 1927.

XXXIV. I. *R. Spärck:* Studies on the Biology on the Oyster (*Ostrea edulis*) V. — II. *Aage J. C. Jensen:* Remarks on the Hydrography of the Limfjord. With 10 figures and 1 table. — III. *H. Blegvad:* Quantitative Investigations of Bottom Invertebrates in the Limfjord 1910—1927 with Special Reference to the Plaice-Food. With 2 figures and 2 tables. — IV. *A. C. Johansen:* The Extent of the Annual Transplantations of Plaice in the Limfjord and the Yield resulting therefrom. With 11 figures and 12 tables. — V. *Aage J. C. Jensen:* The Relation between the Size of the Plaice Stock and the Quantity of "First Class Plaice-Food" in certain Parts of the Limfjord. With 3 figures and 2 tables. — VI. *Erik M. Poulsen:* The Haddock in the Belt Sea and the Western Baltic during the Years 1926—28. With 4 figures and 8 tables. 125 pp. 1928.

XXXV. I. *A. C. Johansen:* The Aalborg Herring and its Importance to the Danish Herring Fishery from the XVIth Century until the Present Day. With 2 figures and 5 tables. II. *H.Blegvad:* Mortality among Animals of the Littoral Region in Ice Winters. With 3 figures. III. *A. C. Johansen:* Mortality among Porpoises, Fish, and the Larger Crustaceans in the Waters around Denmark in Severe Winters. With 2 figures. IV. *R. Spärck:* Studies on the Biology of the Oyster (*Ostrea edulis)* VI—VIII. 109 pp. 1929.

XXXVI. I. *H. Blegvad:* Quantitative Investigations of Bottom Invertebrates in the Kattegat with Special Reference to the Plaice Food. With 1 chart and (8+6) tables. *A. C. Johansen:* The Sprat (*Clupea sprattus* L.) in the Limfjord. With 4 figures and 1 table. III. *Aage J. C. Jensen:* On the Influence of hydrographical Factors upon the Yield of the Mackerel Fishery in the Sound. With 2 figures and 17 tables. IV. *H. Blegvad:* Aerial Spotting of Fish Shoals. Danish Experiments in 1930. With 1 chart. 96 pp. 1930.

XXXVII. I. *H. Blegvad:* Investigations of the Bottom Fauna at Outfalls of Drains in the Sound. With 4 figures and 2 tables. II. *Aage C. Jensen:* Hydrographical Investigations of the Pollution of the Sound at Copenhagen. With 4 figures and 1 table. III. *Erik M. Poulsen:* Analyses of Stock and Race of the Baltic Plaice during recent Years. With 3 figures and 3 tables. IV. *R. Spärck:* Studies on the Biology of the Oyster in the Limfjord. IX. V. *R. Spärck:* On the Capacity of Migration of Adult Individuals of *Asterias rubens.* VI. *R. Spärck & E. Lange:* Preliminary Investigation on the Content of Bacteria in the Limfjord Oyster. VII. *H. Blegvad:* On Aerial Spotting of Fish Shoals. II. Danish Experiments in 1931. With 1 chart. VIII. *H. Blegvad:*Preliminary Report on the Danish Experimental Transplantations of Plaice from the North Sea to the Belt Sea during the Years 1928—31. With 4 figures. 94 pp. 1932.

XXXVIII. I. *H. Blegvad:* S/S "Biologen". With 14 figures. II. *Erik M. Poulsen:* Biology of the Dab in Danish Waters. With 7 figures and 23 tables. III. *R. Spärck:* Investigations on the Biology of the Oyster X. 32 pp. 1933.

Printed by Bianco Luno A/S, Copenhagen.